SOME EFFECTS OF THE DROUGHT DURING THE 1992/93 SEASON

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Abstract

Data from past seasons are reviewed to investigate effects due to drought. Cane tonnage, mixed juice purity and sucrose losses are severely influenced. The quality of the fibre in the cane appears to be affected, particularly in terms of the ratio of pith to hard fibre. Bagasse moisture is higher. High non-sucrose loadings caused many processing problems and there is evidence of high gum levels. Some viscosity trends are presented. Finally, sugar colour tended to be high.

Introduction

During the last 11 seasons, the South African Industry has suffered two severe droughts. Under these conditions the influence of the weather on the cane crop and on factory performance can be so predominant that other factors are of little significance. There is however little specific published data on the effects of drought. Lamusse (1984, 1985, 1986), in various annual reviews, provides a number of general points. Archibald and Smith (1975) comment on the 1974/75 drought on the Natal north coast and describe some of its effects on the pan-house of the Darnall mill. Finally Reid and Wienese (1992) and Lionnet (1992) provide some general information on the 1992/93 drought.

It is not easy to establish clearly cause and effect relationships, when drought is concerned. Thus, the droughts themselves can be different; in 1983/84 there was some rain even during the worst months while in 1992/93 there was almost no rain after November 1991, but dams had water; different geographical regions have different weather conditions; capacities at factories are different and bottlenecks occur in different areas and many effects interact and are difficult to isolate and measure.

The approach taken in this paper has been to select data concerning cane quality and factory performance that are, as far as can be ascertained clearly, affected by drought. The data have been averaged over geographical regions, consisting of the Natal north coast, south coast and midlands, of the irrigated areas of the Pongola and Malelane regions and finally consisting of the whole industry. This geographical breakdown is fairly arbitrary but will be used only for comparison purposes. Finally, various sections of the factory have been considered separately.

The information provided here will inevitably be of a general nature. The main objective of the paper is to collate historical data and various observations pertaining to drought. These will hopefully be of interest to technologists in future years and could highlight areas for research.

Analysis of Historical Data

Some of the highlights of the last eleven seasons, extracted from annual reviews, are as follows:

1983/84 Severe drought affecting most of the industry except SZ and UK. In the midlands the cane showed high sucrose contents but tonnages were reduced. AK, DL and FX1 shut down for a few weeks in mid-season, to allow some growth in the cane.

1984/85 Climatic conditions were good and the industry recovered very well from the 83/84 drought.

1985/86 Mild drought, felt mostly on the north coast and in Zululand.

1987/88 Floods in September 1987. Heavy rains in October, November and December 1987. Eldana counts high in the north coast and Zululand.

The geographical breakdown of the data is summarised in Table 1.

Table 1

Geographical breakdown of data

Mills	Geographical area
ML and PG	North; irrigated cane
UF, AK, DL, GH and FX	North coast
NB, UC and IL	Midlands
SZ and UK	South coast
Industry	—

Arithmetic averages for the mills in each region were used, except for tons cane crushed where the total for each region was used. It should also be noted that, when tonnages are used in the analysis, FX2 has not been included since it started crushing only from 1984/85 onwards. Finally, eleven seasons are considered here, namely 1982/83 to 1992/93.

The approach used to investigate the data is as follows:

- The season average is plotted against time.
- Obvious outliers, usually the values for the 1983/84 and 1992/93 seasons, are noted.
- Linear regressions of the values versus the year number, excluding the outliers, are performed.
- Expected values for the outliers are calculated in one of two ways. If the linear regression is statistically significant, then it is used, if not significant, then the mean value is used.
- The actual value, for the season being an outlier, is compared to the expected value.

Five parameters, namely tons cane, mixed juice sucrose purity, boiling house recovery (BHR), sucrose lost in molasses % in cane, and sucrose lost in undetermined % in cane, have been selected for investigation.

Tons cane

The plots of tons cane crushed against the seasons are shown in Figure 1. The procedure followed will be given in detail here only, for clarity.

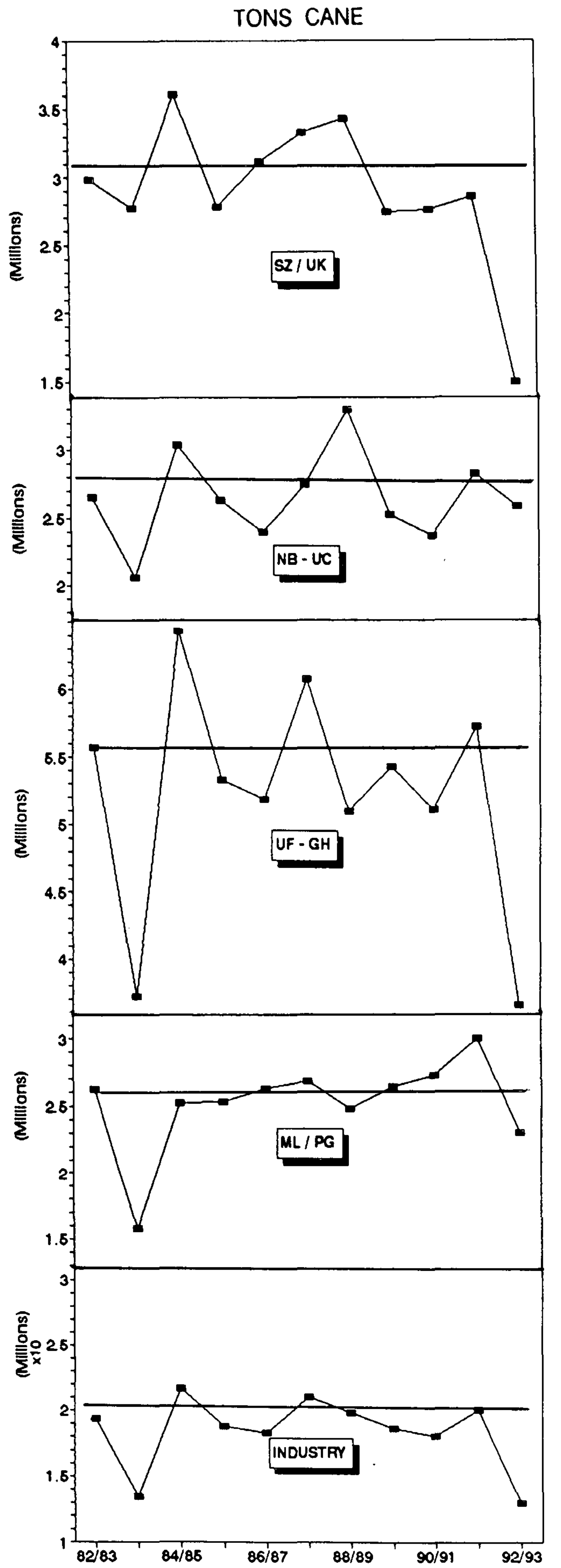

FIGURE 1 Tons cane crushed for each region. The trend lines are shown.

The outlying values for 1983/84 and 1992/93 were removed and linear regressions were performed. Only the ML/PG region showed a statistically significant trend (5%), represented by equation 1:

$$\text{Tons cane} = 2\ 457\ 760 + 32\ 864 \times N \quad \ldots\ldots \quad (1)$$

where N is the year number (1, 2, ... , 11),

which was used to calculate the cane tonnages for 1983/84 and 1992/93. The relevant mean values were used for the other regions. Table 2 can then be prepared. On the basis of the results in this table the cane tonnage was more affected in 1992/93 than it was in 1983/84, probably because of the very low tonnage in the south coast region. The midlands, on the other hand, show only a small reduction.

Table 2

Actual and expected cane tonnages

Region	Calculated for 1983/84	Actual for 1983/84	Actual as a % of calculated	
			1983/84	1992/93
ML/PG	2 523 488	1 574 069	62	82
UF - GH	5 560 358	3 720 414	67	66
NB - IL	2 732 864	2 062 445	76	93
SZ/UK	3 062 698	2 772 610	90	49
Industry	19 543 236	13 422 876	69	66

Mixed juice purity

In this case, all the regressions, except one, are statistically significant and positive, showing that mixed juice purity has been increasing over the period, if the outliers are excluded. The only exception is the south coast region, where the mean has been used. The results have been used to obtain Figure 2 and Table 3.

Table 3

Actual and expected mixed juice purities

Region	Difference in mixed juice purity (Actual - calculated)	
	1983/84	1992/93
ML/PG	− 1,8	− 3,8
UF - GH	− 1,9	− 3,1
NB - IL	+ 0,7	− 1,4
SZ/UK	− 0,6	− 5,3
Industry	− 0,8	− 2,9

Again, on the basis of these results, the recent drought has been worse, with the south coast being severely affected. The results for the midlands in 1992/93 are affected by the severe frost which occurred in June 1992 and cannot therefore be attributed entirely to the drought.

Reference to Figure 2 shows a decrease in mixed juice purity for the 1985/86 season, in the north coast where the drought was felt most that season.

Boiling house recovery

The plot for boiling house recovery is shown in Figure 3. Again significant positive regressions were obtained, except for the south coast. The two droughts are compared in Table 4. The trends found continue here as well. It could be argued that the BHR achieved in 1992/93 is not as bad as could be expected from the mixed juice purities, when compared to the 1983/84 season.

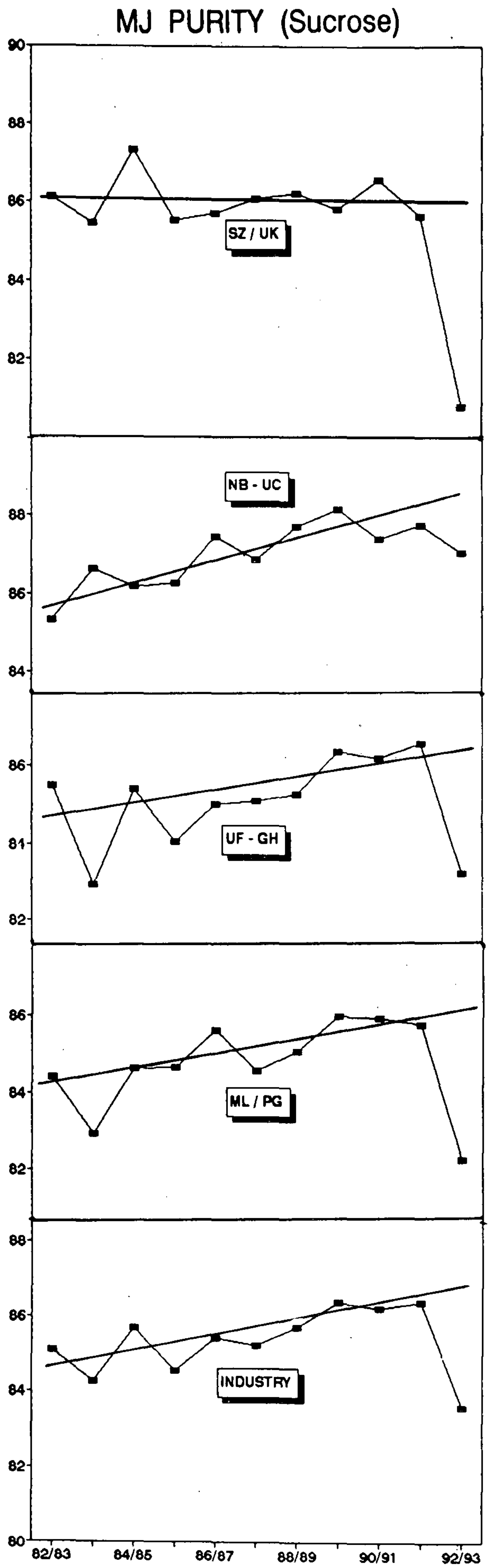

FIGURE 2 Mixed juice sucrose purity and trend lines.

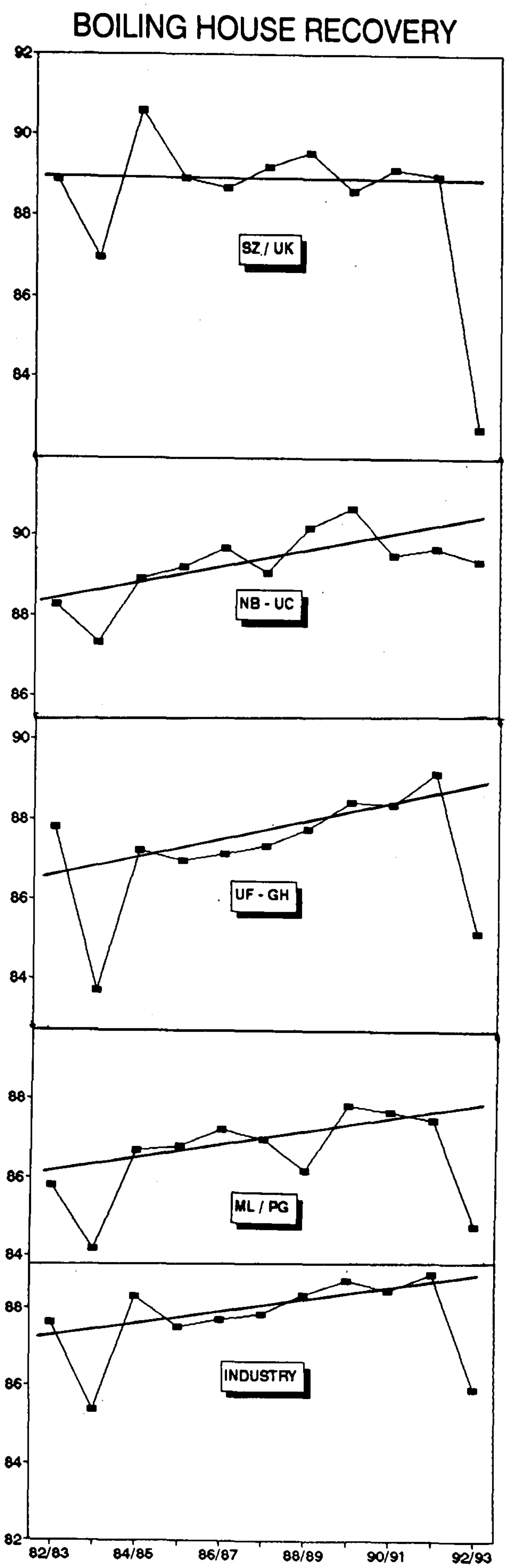

FIGURE 3 Boiling house recovery and trend lines.

Table 4

Actual and expected BHR values

Region	Difference in units of BHR (Actual - calculated)	
	1983/84	1992/93
ML/PG	− 2,1	− 3,0
UF - GH	− 3,4	− 3,6
NB - IL	− 1,5	− 1,0
SZ/UK	− 2,2	− 6,4
Industry	− 2,2	− 2,9

Table 5

Actual and expected values for molasses loss

Region	Difference in units of loss (Actual - calculated)	
	1983/84	1992/93
ML/PG	+ 2,3	+ 2,6
UF - GH	+ 2,3	+ 3,1
NB - IL	+ 1,1	+ 1,1
SZ/UK	+ 1,5	+ 5,7
Industry	+ 1,7	+ 2,5

Table 6

Actual and expected undetermined loss

Region	Difference in units of undetermined loss (Actual - calculated)	
	1983/84	1992/93
ML/PG	+ 0,1	+ 0,1
UF - GH	+ 0,8	+ 0,4
NB - IL	+ 0,4	+ 0,2
SZ/UK	+ 0,5	+ 0,8
Industry	+ 0,7	+ 0,3

Table 7

Extraction and bagasse moisture, for the industry

Season	Extraction	Moisture % bagasse
1990/91	97,75	51,62
1991/92	97,95	51,18
1992/93	97,82	51,92

Molasses loss

The results are shown in Figure 4 and Table 5.

Undetermined loss

In this case, none of the regressions was statistically significant. The results are shown in Figure 5 and Table 6. This is the only parameter which does not show a result which is worse than that of the 1983/84 drought.

Front End of Factory

Generally the extraction plants did not experience problems during the 1992/93 drought. Extraction, although lower than for the 1991/92 season, is still one of the highest on record, but cane throughput tended to be low. Bagasse moisture was generally higher than expected. Results for the last three seasons are shown in Table 7.

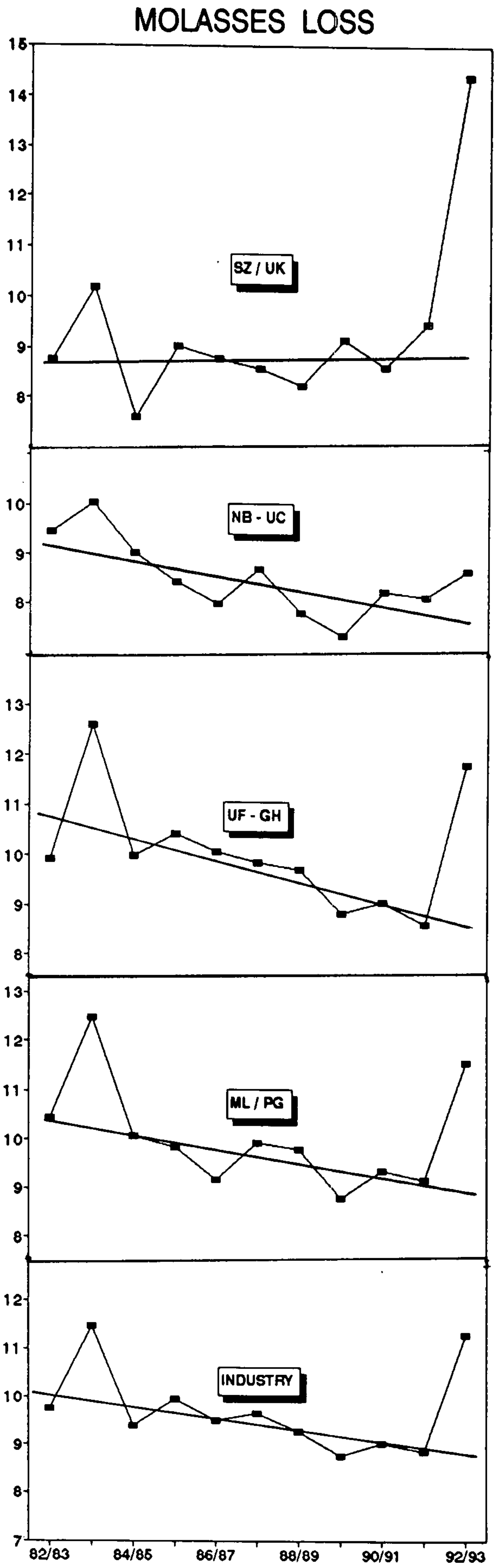

FIGURE 4 Sucrose lost in molasses percent sucrose in cane and trend lines.

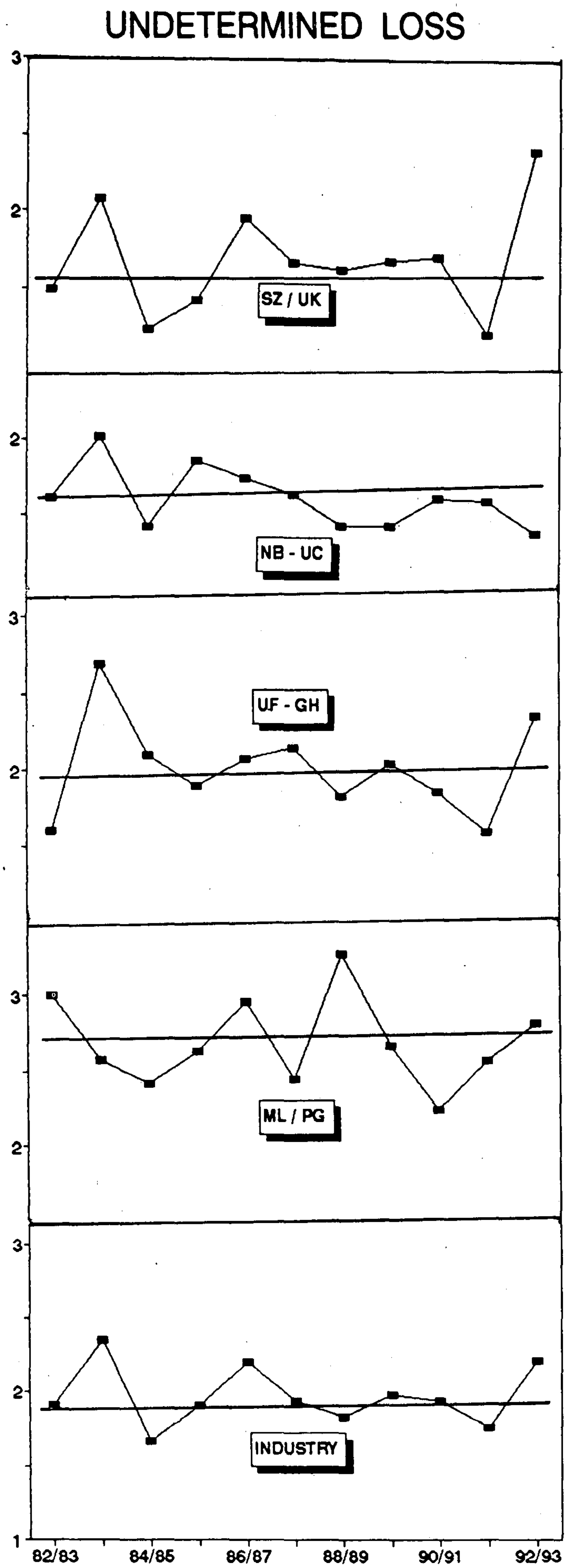

FIGURE 5 Undetermined loss and trend lines.

Cane fibre was quoted to be different during the 1992/93 drought stricken season. The opinion is that there is more pith and less hard fibre in drought cane. This tends to be confirmed by two observations. Firstly although bagasse moistures tend to be higher, no problems from the boiler have been reported, and secondly an increase in bagasse dust has been noticed. Both these observations indicate a higher content of pith.

Crystallisation

Most of the drought related problems, as far as processing is concerned, have occurred during the crystallisation stage. Archibald and Smith (1975) identified two main drought related problems, as far as the pans, crystallisers and centrifugals are concerned. The first is the large increase in non-pol loadings and the second is the 'gumminess' of the massecuites. Both these problems were present during the 1992/93 season.

Non-sucrose loadings

The industrial averages for tons cane crushed per hour and for tons non-sucrose per hour in mixed juice for the last two seasons are given in Table 8.

Table 8

Cane and non-sucrose throughputs, for the industry

	1991/92	1992/93	% Difference
TCH	276	252	− 9
Tons non-sucrose in mixed juice per hour	5,6	6,7	+ 20

Although the cane throughput was lower, the loading in terms of non-sucrose was very high. A number of factories, for example ML, MS and SZ, had extremely high non-sucrose loadings. The differences (1992/93 versus 1991/92) in monthly TCH and non-sucrose in mixed juice per hour at SZ, MS and ML are shown in Figures 6 and 7 respectively. Monthly non-sucrose throughputs show increases of up to 50%. This must have affected performance.

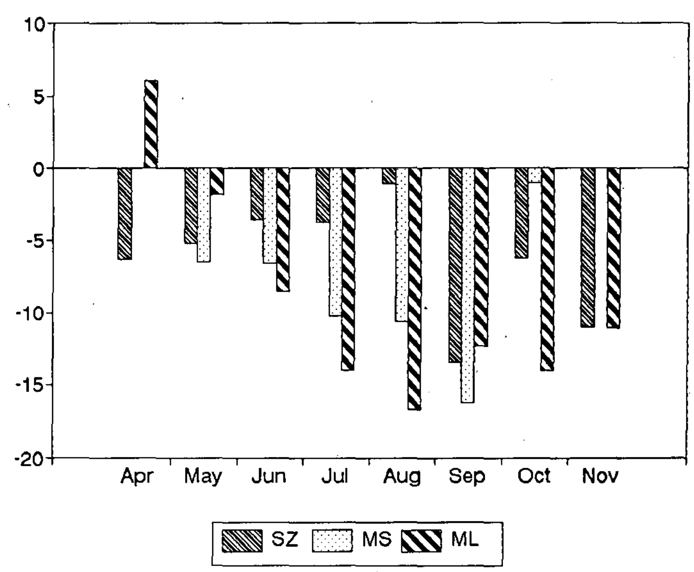

FIGURE 6 Percent difference in TCH at SZ, MS and ML, 1991/92 and 1992/93 seasons.

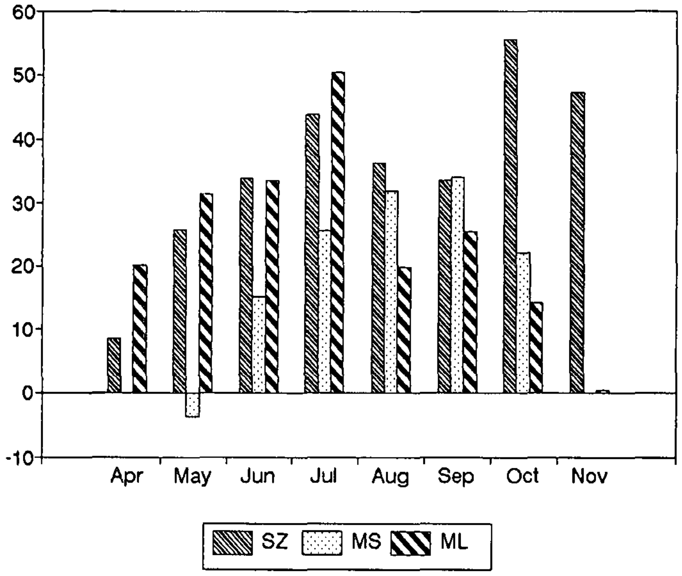

FIGURE 7 Percent difference in the non-sucrose throughput at SZ, MS and ML, 1991/92 and 1992/93 seasons.

Gums

There are indications that drought causes increases in the 'gums' content of cane. It must be noted that the gum analysis is not very specific but depends on the precipitation of alcohol insoluble polysaccharides. Thus the nature of the polysaccharides, for various cane varieties, geographical regions and other agricultural factors, could be very different. Recent work at the Sugar Milling Research Institute indicates that clarification (normal defecation, carried out in the pilot plants of the SMRI) removes 30–60% of the gums found in the mixed juice.

Many samples of evaporator syrup have been boiled into A-massecuites in the SMRI pilot pan over the last five years. The boilings are done under standard conditions and reproducible results are obtained. Boilings done over the period April to July 1992, using syrups from IL, ME and SZ yielded A-sugars containing many dark lumps, a phenomenon which had never been found previously. These lumps were separated manually. They dissolved in water and the colour was similar to that of the massecuite. Inspection under the microscope showed that they consisted of crystals embedded in mother-liquor. Preliminary tests involving alcohol precipitation showed that high levels of alcohol insoluble material were present. In view of these results it was tentatively concluded that the lumps were not caused by thermal effects in the pan and that gums could be involved. A-molasses from these boilings and from previous boilings, done in 1991 and which showed no lumps, were analysed for starch and gums. The results are in Table 9. Although there was no difference in the starch contents, the gums were much higher in 1992. Lumps were also found in the sugar at SZ. These lumps showed 1570 ppm of gums, whereas the lump free sugar showed only 600 ppm.

Table 9

Gums and starch (ppm on brix) in A-molasses from the SMRI pilot pan

Date of boiling	Origin of syrup	Gums (ppm on brix)	Starch (ppm on brix)	Remarks
Aug–Nov 1991	IL, ML, GH	9 410	1 230	No lumps
Apr–July 1992	IL, ME, SZ	15 940	1 125	Lumps present

Morel du Boil (1993) has commented on the dextran content in the VHP sugar produced during the 1992/93 season. After considering various factors such as the shorter season and the smaller number of mills supplying the Terminal, it was concluded that dextran levels were exceptionally low. The two major suppliers (SZ and FX) produced VHP with 155 to 161 ppm of dextran (Roberts Method), which is about 100 ppm lower than previous levels. Possible reasons for the low concentrations include climatic effects (extremely dry and relatively cool weather), smaller crystals and more burnt cane.

Fouling of centrifugal screens

Fouling of B-and C-centrifugal screens was reported by some factories. It was severe at SZ, where samples of the scale were removed and sent to the SMRI for analysis. Some results are shown in Table 10.

Table 10

Analysis of scale from industrial centrifugal

	Scale from a B basket	Scale from a B screen
Moisture % scale	4,9	5,8
Ash % scale	52,2	42,5
CaO % ash	54,0	60,7
Silica % ash	19,4	2,8
Sulphate % ash	20,7	9,2

In both cases, the scale was more than 50% inorganic in nature. The major ash constituents were calcium, silica and sulphate. Analyses for aconitic acid were inconclusive.

Chemical additives

Sodium hydrosulphite is used at times of processing difficulties and Koster *et al.* (1992) show that this chemical can help. Dosages vary between 150 and 400 ppm on massecuite.

Samples of A-, B- and C-massecuites were treated at the SMRI. They were heated to 60°C and 0 to 600 ppm of sodium hydrosulphite were added, mixed well and the samples were kept at 60°C for 2, 3 and 5 hours, in the case of A-, B- and C-massecuites, respectively. There were no measurable changes in purity, reducing sugar/ash ratios, fructose/glucose ratios or pH. Two sets of syrup boilings in the SMRI pan were also done.

A first sub-sample was boiled as such while 400 ppm of sodium hydrosulphite was added to the other. In both cases the affinated sugar colour was lower (12 and 4%) but the molasses colour was reduced by the chemical (13%) only in one of the two experiments. The addition of sodium hydrosulphite reduced the molasses viscosity in both cases, by 30 to 50%.

Dextranase was tested in one boiling and found to reduce viscosity by about 25%.

Crystal size analysis in C-massecuite

Monthly samples of C-massecuite are sent to the SMRI for the determination of crystal length and width. The results obtained for the last two seasons are plotted in Figure 8.

The average crystal size was somewhat lower in 1992/93. There is however a major consideration when crystal size is measured at the SMRI. The measurement is done by a computer based, image analysis system. This involved locating a pointer first at one end of the crystal and then at the other. The two positions then give the measurement of the crystal.

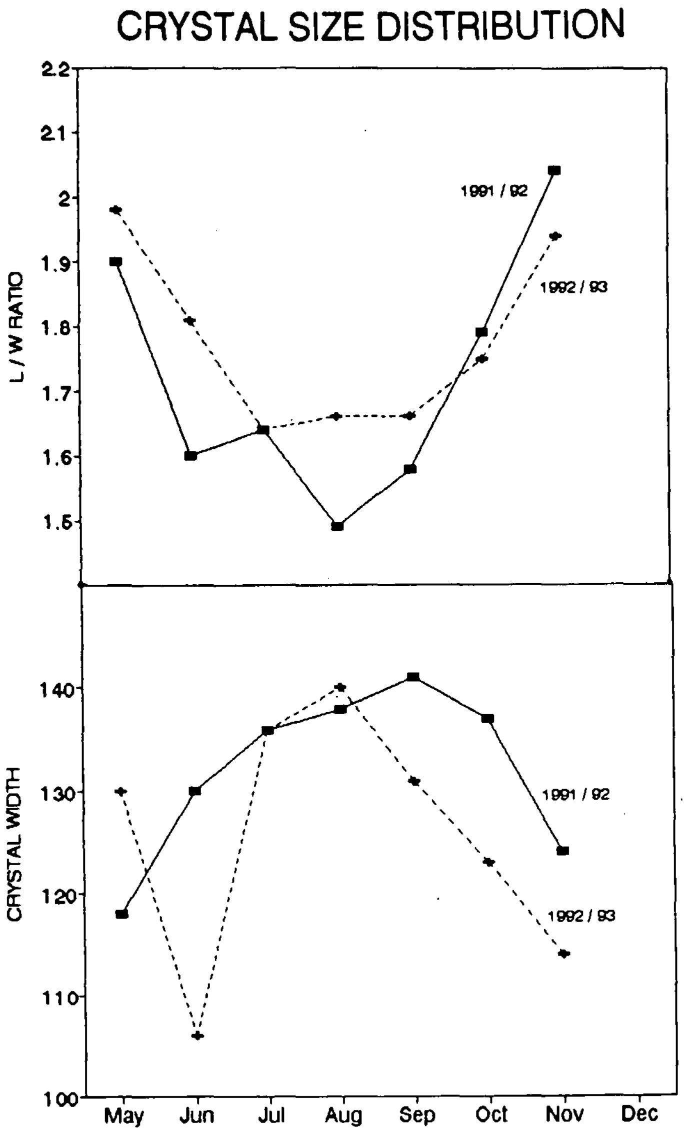

FIGURE 8 Average C-crystal width (μm) and average length to width ratio, for the 1991/92 and 1992/93 seasons.

Generally this technique is adequate but it fails when crystals which are smaller than 20 μm are present, since the pointer cannot be used with these small crystals. The method is thus not adequate when false grain or very small crystals are present in the massecuite. In those cases, an empirical (and subjective) assessment is made by the operator to classify the massecuite as having 'light' or 'heavy' false grain/small crystals, and only the bigger crystals are measured. These classifications for the last two seasons are shown in Table 11. As can be seen from this table no samples showed small grain in 1991/92. In 1992/93, however, between 9 and 13 of the 16 samples recorded every month showed false grain,

Table 11

Presence of false grain/small crystals in C-massecite. Each figure represents the number of samples showing false grain/small grain

Month	1991/92		1992/93	
	Light	Heavy	Light	Heavy
May	—	—	—	—
June	—	—	10	1
July	—	—	10	1
August	—	—	7	2
September	—	—	5	4
October	—	—	4	9
November	—	—	2	7

with the trend towards the 'heavy' category increasing in September, October and November.

Viscosity

The viscosity of final molasses from selected factories was measured at the SMRI during the 1990/91 and 1992/93 seasons. In all cases, the weekly final molasses samples and a Brookfield HBT, with spindle number two, were used and the measurements were done at 30°C.

The brix (or dry solids) of the molasses has a very pronounced effect on the viscosity or consistency. A 0,1 unit change in brix can cause a change of up to 10% in the molasses consistency. This makes comparisons difficult, even if the temperature at which the measurement is done is well controlled. Final molasses viscosities for IL and SZ are compared in Table 12. Bearing in mind the comments made earlier on comparisons of viscosity, the results of Table 12 show that viscosity tended to be higher in 1992/93.

Target purity difference

The presence of small grain in C-massecuite and higher viscosities would both cause the target purity difference (TPD) to increase. TPD levels, for the whole industry, for the 1991/92 and 1992/93 seasons, are shown in Table 13.

Table 13

TPD for the Industry, for the last two seasons

Month	TPD		Difference (units)
	1991/92	1992/93	
April	—	7,0	—
May	4,9	6,0	+ 1,1
June	3,0	4,9	+ 1,9
July	3,4	4,9	+ 1,5
August	3,4	5,1	+ 1,7
September	3,3	5,9	+ 2,6
October	4,2	6,2	+ 2,0
November	4,5	6,7	+ 2,2

Table 12

A comparison of molasses viscosities (Pa.s) for a normal season (1990/91) and a drought season (1992/93)

Month	SZ				IL			
	1990/91		1992/93		1990/91		1992/931	
	Brix	Viscosity	Brix	Viscosity	Brix	Viscosity	Brix	Viscosity
July	81,2	13,1	81,3	11,5	80,8	12,0	80,8	10,6
August	80,7	11,0	80,2	12,9	80,9	11,3	80,5	12,4
Sept.	79,3	11,7	79,78	19,9	84,0	14,4	80,0	22,9
Oct.	79,2	17,4	0,1	21,7	80,7	25,2	79,6	22,4

In all cases, the values for the 1992/93 season are higher, particularly in September, October and November, which correspond to the 'heavy' category of small grain. These results therefore seem to confirm those in Tables 11 and 12.

Sugar Quality

Drought is known to cause large increases in sugar colour. This is evident in Figure 9. Although the VHP colours (1651 and 1637), are nearly identical for the two drought stricken seasons the affinated sugar colour in 1992/93 (853) is lower than in 1983/84 (1016). This decrease in affinated colour could be caused, at least partly, by two factors. Firstly, the use of sodium hydrosulphite at most mills must have reduced colour. Secondly, and probably more importantly, the percentage of burnt cane was much higher in 1992/93 (85,0%) than in 1983/84 (60,4%). It has been well established, both in the laboratory and in full scale work, that trash adds a considerable amount of colour to the process. Drought also affects sugar pol (and purity). Over the last 11 seasons, the lowest VHP pol values were 99,35 and 99,36 in 1992/93 and 1983/84 respectively.

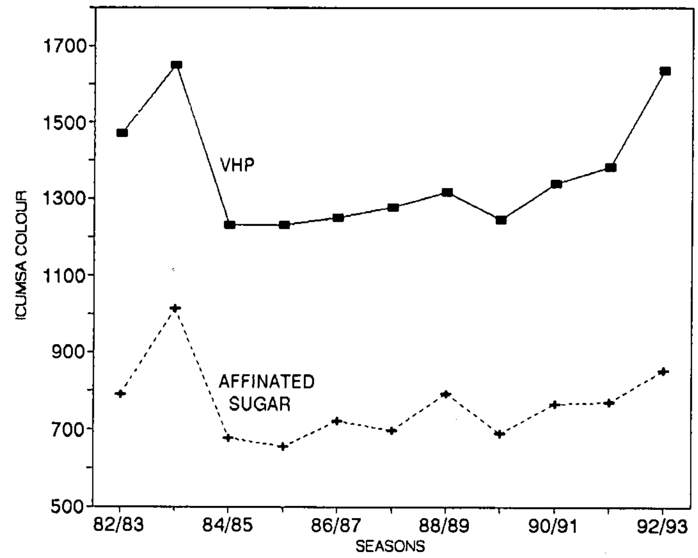

FIGURE 9 Trends in VHP (total sugar) and affinated sugar (export only) colours, over the last 12 seasons.

Conclusions

Analyses of historical data show that cane tonnage, mixed juice purity, BHR and losses in molasses are severely affected by drought. Difficulties in the factory occur mostly during crystallisation. Two factors are the main causes of these difficulties. The first is the large increase in non-sucrose loadings and the second is related to high concentrations of gums, associated with high viscosities. Massecuite quality, particularly in terms of the presence of small grain, deteriorates and TPD suffers. Sugar quality, both in terms of pol and colour, deteriorates.

A clear result of the observations given here is the need to investigate 'gums' in more detail.

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