EXTRANEOUS MATTER IN CANE AND ITS EFFECT ON THE EXTRACTION PLANT

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Abstract

Data are given on extraneous matter content of cane. The results of industrial scale tests to find the effect of a reduction in trash content of cane on the capacity and efficiency of a milling train and cane diffuser are discussed. An estimate is made of additional transport and maintenance costs, loss of sugar production and increase in length of season which can be attributed to extraneous matter in cane.

Introduction

During the past few years the subject of extraneous matter in cane and its influence on factory performance and costs has been reported by several authors in South Africa.

Scott[1] has described the results of tests in which the influence of trash and tops on mill capacity was investigated. Cargill[2] has costed the effect of extraneous matter in cane for the industry. Smits and Blunt[3] have described the effect of extraneous matter in cane on factory operation and maintenance. Scott *et al*[4] have estimated on a laboratory scale the effect of tops and trash on juice quality and extraction. During the 1978/79 season the SMRI has collected data from most mills on the extraneous matter content of cane. Tests were also carried out in 1977 and 1978 to measure the effect of trash in cane on the capacity and performance of a milling tandem and of a cane diffuser. The results of the survey and of the milling tests are reviewed below.

Extraneous matter in cane

For the purpose of the survey, extraneous matter in cane has been subdivided into :

Trash
Tops
Sand and soil

Data on trash and tops have been provided by Huletts from analyses carried out on a routine basis at their five mills and the average results of the past four seasons for the Huletts group are summarised in Table 1. They indicate a reduction in both trash and tops content. In some of the mills the reduction has been very marked, e.g. at Amatikulu, trash + tops dropped from 7,4% in 1975/76 to 4,5% in 1978/79.

TABLE 1
Trash and tops content of cane (Huletts Group)

Season	Trash	Tops	Trash + tops
1975/76	5,60	3,00	8,60
1976/77	5,48	2,48	7,96
1977/78	5,06	2,76	7,82
1978/79	5,02	2,27	7,29

In practice, sand and soil in cane cannot be measured as such and it is assumed that ash % cane is a measure of the extent of their presence in cane. This inferential method has been thoroughly investigated and it has been found that ash content of clean cane averages 0,6%[5]. This value should be deducted from the ash found in prepared cane. It is evident that the ash content of soil will be lower than the weight of soil because of loss of moisture and organic matter during calcination. Both these components however are of little importance if one considers the objectionable properties of soil in cane.

Fourteen mills reported weekly values of ash % cane to the SMRI during the 1978 season. These and the results of trash and tops analyses reported by the five Huletts mills are summarised in Table 2.

TABLE 2
Extraneous matter in cane (weekly average values)

	Maximum	Minimum	Average
Tops % cane (5 mills)	4,4	1,1	2,1
Trash % cane (5 mills)	12,0	1,6	5,3
Ash from soil % cane (14 mills)	5,6	0	1,0
Total ash % cane (14 mills)	6,2	0,5	1,6
Total extraneous matter % cane	17,7	4,5	9,0

The maximum and minimum values listed in the table are the highest and lowest weekly average values reported by any mill. Corresponding results for individual determinations show far greater differences between maximum and minimum values. Total extraneous matter reported in the table is the sum of trash, tops and ash. In the case of cane with a high sand and soil content, an error is introduced because some of the sand is measured as trash.

Changes in ash, tops and trash content of cane occur during the season. They are generally related to rainfall and increase during the rainy season towards the end of the year. The influence of rainfall on ash % cane is shown clearly in Figure 1 in which data for Union Co-op have been plotted. Normal

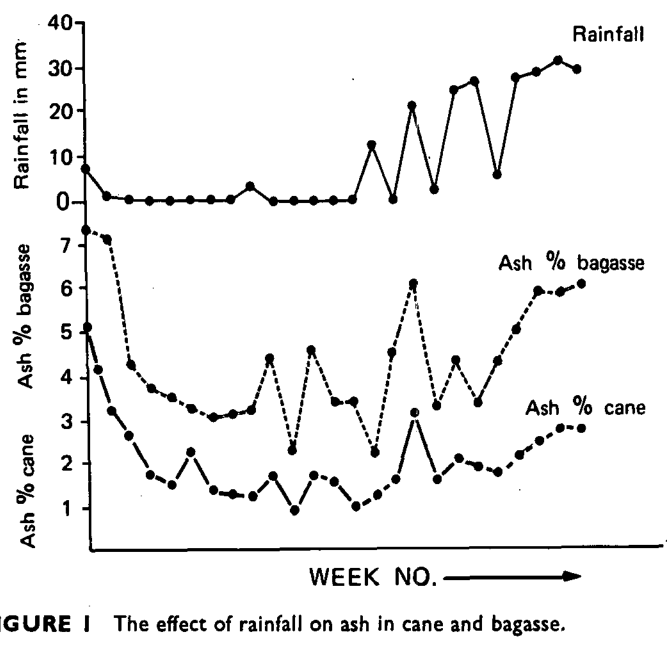

FIGURE 1 The effect of rainfall on ash in cane and bagasse.

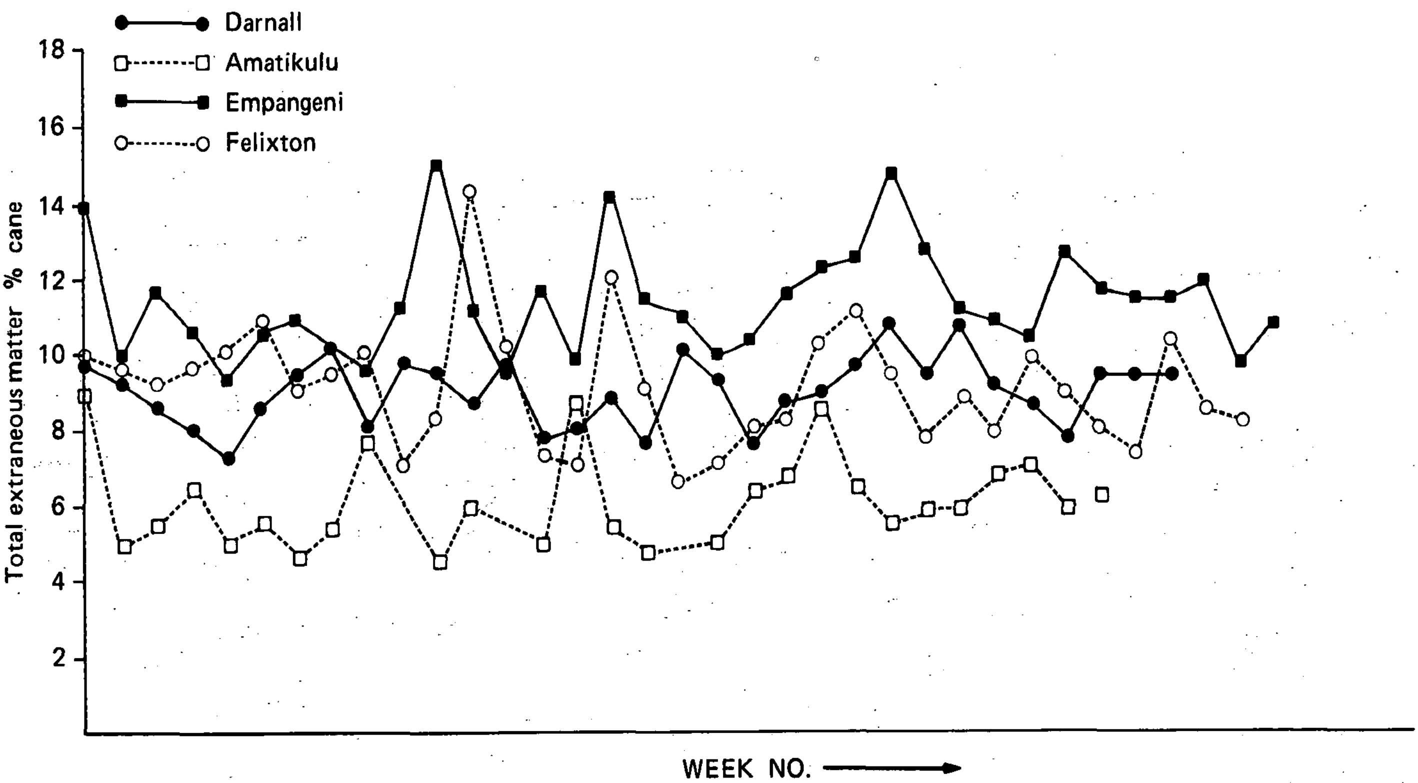

FIGURE 2 Weekly variations in extraneous matter content of cane.

week to week variations in extraneous matter content of cane from four mills have been plotted in Figure 2. No trend can be detected.

Extraneous matter in bagasse

In bagasse, fibre in trash and tops cannot be distinguished from cane fibre. The only measurable extranenous matter in bagasse is sand and soil. As for cane, total ash in bagasse is used as a measure of sand and soil content. The net value of extraneous matter in bagasse can be obtained after subtracting the ash content of clean bagasse (0,6%).

Maximum, minimum and average values obtained by screening weekly average data reported by fourteen mills are listed in Table 3. They range from a maximum of 8,57 for ash from soil in bagasse to a minimum of 0,01 with an average of 2,10.

TABLE 3
Ash in bagasse (weekly average value from 14 mills)

	Maximum	Minimum	Average
Total ash % bagasse	9,17	0,61	2,70
Ash from soil % bagasse . . .	8,57	0,01	2,10

Effect of type of extraction plant on ash in bagasse

Sand and soil in bagasse are responsible for considerable damage to boilers and ancillary equipment. They also create problems in cleaning of furnaces. An attempt has therefore been made to correlate ash in cane to ash in bagasse. Good correlations have been obtained. Typical curves are given in Figure 3 (NB, correlation coefficient 0,89) and Figure 4 (UC, correlation coefficient 0,85).

Data from the factories have also been grouped according to type of extraction plant (cane diffusers, bagasse diffusers, mills).

NB ASH % CANE VS ASH % BAGASSE

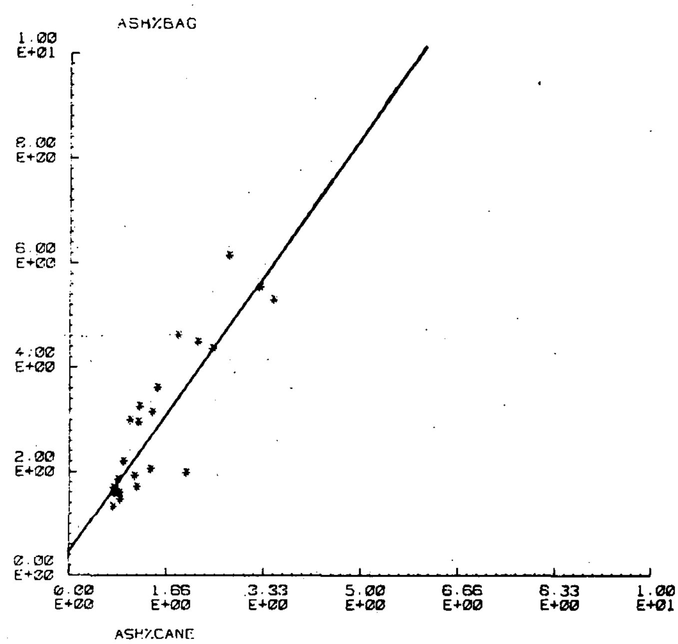

FIGURE 3 Relation between ash in cane and ash in bagasse NB.

Data from Felixton, Umfolozi, Noodsberg and Umzimkulu have been used to plot the relationship for straight milling tandems (Figure 5) and a second order equation with a correlation coefficient of 0,95 has been obtained.

In the case of cane diffusers data from Union Co-op, Tongaat, Malelane, Amatikulu and Gledhow were plotted in Figure 6 and yielded a second order equation with a correlation coefficient of 0,85. Because of the limited number of data, which were obtained only from Empangeni and Pongola, the equation for bagasse diffusers, derived from Figure 7, has a correlation coefficient of only 0,57.

The formulae linking ash in bagasse and ash in cane for the three types of extraction plant are listed below.

Mills $Y = -0{,}023 + 2{,}043X - 0{,}0926X^2$

Cane diffusers $Y = -0{,}392 + 2{,}879X - 0{,}271X^2$

Baggasse diffusers. $Y = 2{,}023 + 0{,}875X$

Where Y = Ash % bagasse

X = Ash % cane

Using these formulae, it can be calculated that for an ash % cane value of 2, the ash in bagasse will be:

3,7% for mills
4,3% for cane diffusers
3,8% for bagasse diffusers

The ash in bagasse values are very nearly the same for mills and bagasse diffusers. This indicates that in the bagasse

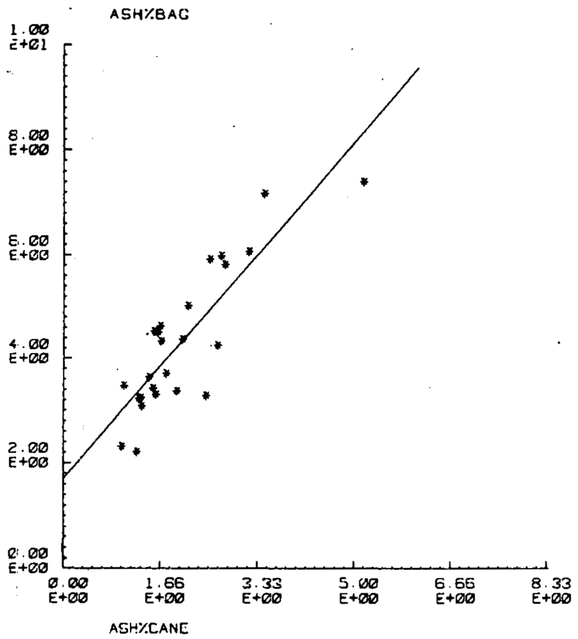

FIGURE 4 Relation between ash in cane and ash in bagasse UC.

ASH % C VS ASH % B: MILLS

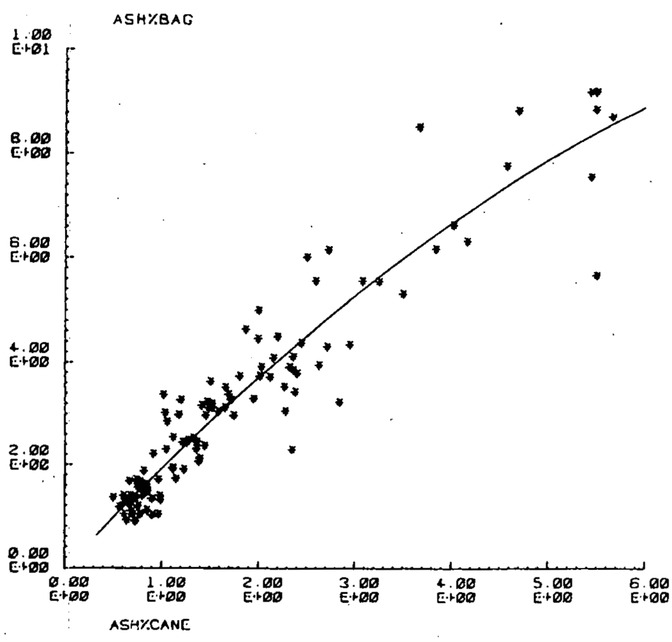

FIGURE 5 Relation between ash in cane and ash in bagasse for mills.

diffusers at PG and EM the amount of sand and soil recirculated in secondary juice is about the same as for milling tandems.

Effect of burning cane on extraneous matter content

A series of tests was carried out at Tongaat in 1977 and 1978 on milling of burnt and unburnt cane. For these tests, cane from the normal supply to the mill was segregated into burnt and unburnt with no attempt to have replicate plots. Burning was not controlled and was resorted to as a practical method of cleaning cane.

Cane was sampled from the feeder table and analysed for trash and tops while ash % cane was determined on com-

ASH % C VS ASH % B: C DIFFUSERS

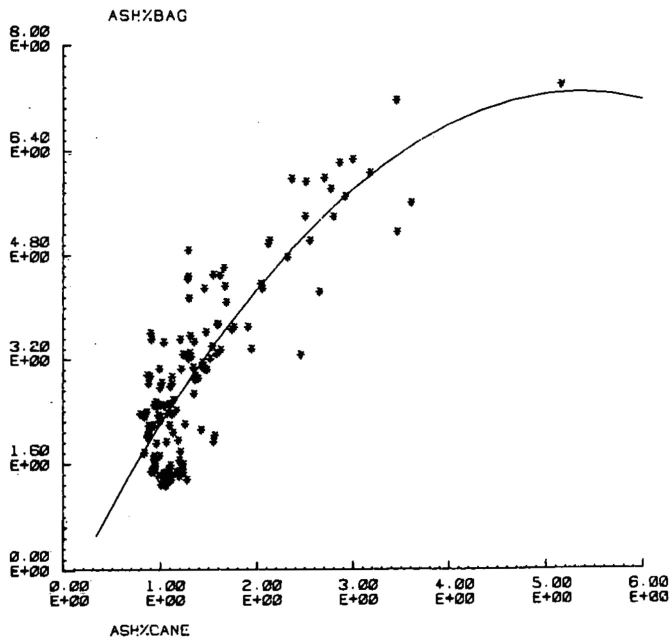

FIGURE 6 Relation between ash in cane and ash in bagasse for cane diffusers.

ASH % C VS ASH % B BAG DIFFUSERS

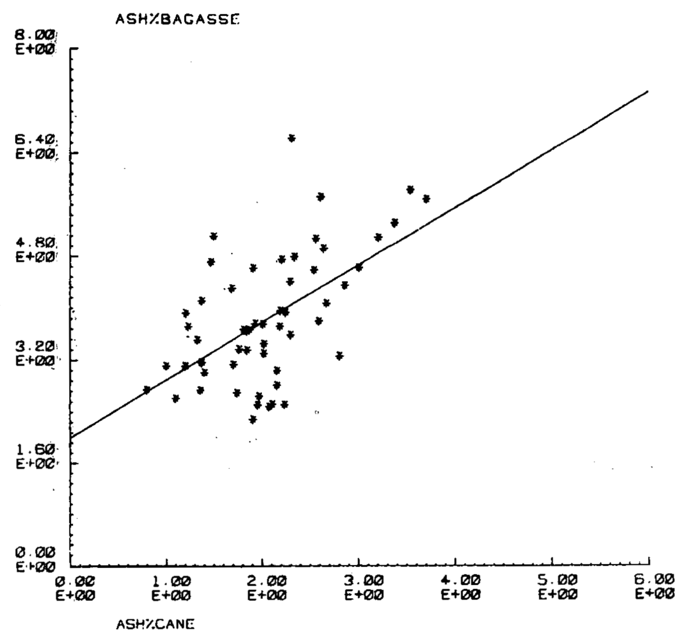

FIGURE 7 Relation between ash in cane and ash in bagasse for bagasse diffusers.

TABLE 4
Extraneous matter in burnt and unburnt cane (Tongaat tests)

	Burnt	Unburnt
Tops % cane	2,4	2,5
Trash % cane	7,4	12,2
Total ash % cane	1,2	1,2
Ash from soil % cane	0,6	0,6
Total extraneous matter % cane	11,0	15,9

posite samples of shredded cane. The sampling and analytical procedures have been fully described elsewhere[6].

Average results of the tests are listed in Table 4. They show a decrease of about 5% in the trash content of cane as a result of burning. There was no significant effect on tops or ash content of cane.

Influence of reduction in trash content on cane transport cost

Most of the cane processed during the Tongaat tests was supplied to the mill in 20-ton Hilo trailers, the cane being loaded loose. The weight of each load was logged and it was found that, due to better packing of the cleaner cane, the average weight of a load of burnt cane was 20,63 tons while that of unburnt cane was only 18,90 tons; a difference of 1,73 tons.

Influence of burning cane on mill throughput, performance and power

Nine pairs of tests were carried out on burnt and unburnt cane on the Tongaat milling tandem. These tests were carried out under normal operating conditions and comparative runs of at least six hours duration each were made within twenty four hours of each other. Mill settings and speeds, imbibition rate etc were the same for each pair of tests. Overall results of all runs are listed in Tables A and B in the appendix. The results of the tests can be divided into three main groups which are discussed below :

1. *Throughput*

Tons of cane and fibre processed are listed in Table 5. The increase in throughput as a result of a reduction of 5% in trash content was 27 tons of cane per hour or 15% which confirms Scott's[1] findings. Comparison on the basis of tons of fibre per hour indicates that the higher throughput was due only to the lower fibre content of burnt cane.

TABLE 5
Mill throughput (Tongaat tests)

	Tons cane per hour	Tons fibre per hour
Burnt	203	29
Unburnt	176	29
Difference (burnt-unburnt)	27	Nil

2. *Milling efficiency*

An analysis of the figures listed in Table 6 shows that average extraction was 97,16 for burnt cane and 96,69 for unburnt cane. However pol % bagasse and moisture % bagasse were very nearly the same in both cases, again indicating that the higher extraction was due to a lower weight of bagasse produced as a result of the reduction in the fibre content of cane caused by burning.

The slightly higher corrected reduced extraction with unburnt cane may be due to the fact that imbibition, although kept constant, was higher when expressed on fibre for unburnt cane.

TABLE 6
Milling efficiency (Tongaat tests)

	Burnt	Unburnt
Extraction	97,16	96,69
Corrected reduced extraction	96,79	96,94
Pol % bagasse	1,16	1,12
Moist. % bagasse	53,7	53,4
Imb. % fibre	262	270

3. *Power taken by preparation equipment.*

The power taken by the electric motors driving the three knives sets was logged by totalising ammeters. The shredder was driven by a steam turbine and its power consumption was estimated from nozzle and turbine speed readings taken at ten minute intervals.

TABLE 7
Power taken by cane preparation equipment (Tongaat tests)

		Burnt	Unburnt	% Change
Lower knives	kWh/t cane	0,78	0,92	18
	kWh/t fibre	5,65	5,81	3
Middle knives	kWh/t cane	0,59	0,71	20
	kWh/t fibre	4,27	4,47	5
Top knives	kWh/t cane	0,99	1,18	19
	kWh/t fibre	7,17	7,42	3
Shredder	kWh/t cane	3,03	3,66	21
	kWh/t fibre	21,34	22,35	5

Inspection of Table 7 reveals that power taken by the knives and by the shredder was 18 to 21% higher with unburnt cane when power was expressed in terms of kWh per ton of cane per hour. Converted to kWh per ton of fibre, unburnt cane took only 3 to 5% more power. Again, the effect of the higher fibre content of unburnt cane was preponderant but the fact that kWh/per ton fibre was also higher for unburnt cane indicates that "quality" of fibre plays a part in the power consumed by preparation equipment.

Influence of trash reduction on diffuser operation

Six comparative runs were carried out with burnt and unburnt cane on the BMA cane diffuser at Tongaat. For each pair of tests the speed of the diffuser conveyor and imbibition flow rate were kept constant. The results of these tests are in agreement with those of the milling tests as far as power requirements of cane knives are concerned. Power taken by the shredder could not be measured.

The level of cane in the feed chute to the diffuser at Tongaat controls carrier speed and therefore cane throughput. This control may have limited feed to the diffuser when processing unburnt cane and contributed to the increase of 48 tch or 24% obtained with burnt cane.

The main results of the diffuser tests are listed in Table 8. They show that the effect of burning on extraction is not as marked as with mills. It was only 0,06 in favour of burning. This small difference can be explained by the influence of imbibition % fibre. For the diffuser tests, imbibition water flow rate was kept constant and, because of the lower fibre throughput, imbibition % fibre was higher for unburnt cane. As a result, pol % bagasse was lower by 0,14 points and has compensated, to a certain extent, for the influence of the increase in weight of bagasse per ton of cane when processing unburnt cane.

TABLE 8
Results of processing burnt and unburnt cane in a diffuser (Tongaat tests)

	Burnt	Unburnt
Tons cane per hour	249	201
Tons fibre per hour	38	34
Average bed height (cm)	145	125
Bed speed m/min	1,2	1,2
Extraction	96,97	96,91
Corrected reduced extraction	96,78	97,13
Imbibition % fibre	232	263
Pol % bagasse	1,18	1,04
Moisture % bagasse	54,8	55,5

Conclusions

The work done so far in South Africa on extraneous matter in cane has been based either on localised sampling or on only some constituents of extraneous matter.

The results of the survey reviewed in this paper provide, for the first time, industry-wide results based on the same analytical procedure. Earlier investigations can be confusing because sand or ash in cane and bagasse have not always been reported on the same basis.

This survey and the Tongaat tests have provided sufficient data to estimate and to cost some of the effects of extraneous matter supplied to the mills with cane. The data are however insufficient to have a full picture of the cost of these impurities on sugar production. Industry-wide data on the influence of sand and soil on milling costs are missing and only laboratory test results are available to estimate the effect of trash and tops on boiling house recovery.

Results discussed in this report have been used to cost some practical effects of extraneous matter. The costs have been worked out for a mill processing one million tons of clean cane per season at 200 tons of cane per hour. Transport distance and cost have been assumed at 20 km and R0,08/ton km respectively.

Sand and soil % cane (max. 5,6%. Ave. 1,0%)

A maximum of 56 000 tons and an average of 10 000 tons of sand and soil would be transported per season. Additional transport costs would be R90 000 and R16 000 respectively.

No accurate costs are available for damage to factory equipment. It has been estimated by Smits and Blunt[3] at R182 000 in 1975, which would be over R200 000 at today's costs.

Tops in cane (max. 4,4%. Ave. 2,1%)

Tonnage involved would be : maximum 44 000 tons, average 21 000 tons. Transport of tops would cost R70 000 and R34 000 respectively. The tops would also reduce factory capacity and proportionately increase length of season. At 80% time efficiency they would cause an increase of 6 days at average tops content and 12 days at maximum tops level.

Trash % cane (max. 12,0%. Ave. 5,3%)

The tonnages of trash under maximum and average conditions would be 120 000 and 53 000 tons respectively. The transport cost of this additional weight of material would be R192 000 and R85 000. Allowance must also be made for the increased load of vehicles when carrying trash free cane as discussed earlier in this report. The effect of trash on factory throughput has been measured at 15% for a 5% change in trash content. For the average trash content (5,3%), the corresponding increase in length of season would be 62 days. Extrapolation of results obtained to the maximum trash level of 12% would lead to an increase of no less than 195 days in the duration of the season. At an estimated R10 000 per day the longer season would cost R620 000 and R1 950 000 respectively. Loss in extraction because of trash would be equivalent to 500 tons of sugar for cane containing 5,2% trash and 1 100 tons for cane with 12% trash.

The cost of extraneous matter in cane *at average industrial level* for a typical South African factory can be summarised as follows :

Season lengthened by 68 days (estimated cost R680 000).
Sugar production decreased by at least 500 tons (estimated cost R75 000).

Transport costs increased by R135 000.
Factory maintenance costs increased by R200 000.

In addition extraneous matter will have a detrimental effect on boiling house recovery which is far from negligible but which has not so far been investigated under industrial conditions in South Africa.

Acknowledgement

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APPENDIX—TABLE A

Results burnt and unburnt cane test — 1978

RUN NO.	10A	10B	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B
Date	22/6/78	22/6/78	29/6/78	29/6/78	18/7/78	18/7/78	19/7/78	19/7/78	20/7/78	20/7/78	21/7/78	21/7/78
Trashed/Burnt	Burnt	Trashed	Burnt	Trashed	Burnt	Trashed	Burnt	Trashed	Burnt	Trashed	Burnt	Trashed
Tons Cane/h	186	180	221	171	195	165	178	168	192	170	190	178
Tons Fibre/h	24,3	28,8	28,8	26,5	27,3	26,6	25,4	26,3	27,2	27,9	26,3	27,6
Tons Imb./h	70	70	71	71	70	70	70	70	70	70	70	70
Net duration of run (h)	3,68	3,72	3,80	3,30	3,45	3,50	3,90	2,75	3,90	2,81	4,00	3,50
Pol % Cane (Dac)	12,8	12,1	13,0	12,4	12,9	12,8	13,2	12,9	13,4	12,4	14,0	12,7
Fibre % Cane (Dac)	13,1	16,0	13,1	15,5	14,0	16,1	14,3	15,6	14,2	16,4	13,8	15,4
Brix % Cane (Dac)	15,1	14,7	15,4	15,0	15,5	15,4	15,7	15,4	15,9	15,1	16,4	14,4
Non Pol % Cane (Dac)	2,3	2,6	2,4	2,6	2,6	2,6	2,5	2,5	2,5	2,7	2,4	1,7
Insol. Solids in M.J. % Cane	0,65	0,81	0,64	1,00	0,87	0,85	0,43	0,63	0,60	0,59	0,75	0,77
Trash % Cane	11,50	10,50	3,24	9,40	6,99	11,88	8,51	12,11	4,63	11,40	7,24	13,98
Tops % Cane	1,80	3,00	3,71	4,27	2,50	2,78	2,98	2,00	2,62	2,08	2,64	2,06
Ash % Cane	—	—	2,52	2,51	0,80	0,80	1,00	1,20	1,40	1,00	1,00	0,80
Pol % Bag.	1,11	0,98	1,05	0,84	0,93	0,98	1,01	0,92	1,00	0,88	1,01	0,96
Brix % Bag.	2,50	2,36	2,22	2,22	1,94	2,23	1,96	0,96	1,92	1,95	2,06	2,05
Fibre % Bag.	45,42	45,61	43,43	43,84	45,36	46,77	44,54	45,68	45,28	44,76	43,60	46,23
Moisture % Bag.	52,08	52,03	54,35	53,94	52,70	51,00	53,50	53,36	52,80	53,29	54,34	51,72
Ash % Bag.	—	—	2,18	2,06	1,20	1,40	1,20	1,00	1,80	1,40	1,20	1,40
Extraction (Dac)	97,50	97,16	97,54	97,58	97,78	97,43	97,58	97,60	97,66	97,42	97,71	97,48
Corrected Reduced Extraction	96,99	97,42	97,00	97,65	97,51	97,54	97,32	97,63	97,36	97,66	97,26	97,50
Imb. % Fibre	288	243	247	268	256	263	276	266	257	251	266	254
Tons Cane/Hilo	20,37	18,96	20,36	18,33	21,05	17,90	20,64	18,48	19,24	18,50	18,32	17,93

APPENDIX— TABLE B

Results burnt and unburnt cane tests — 1977

RUN NO.	1	2	3	4	5	6	7	8	9
Date	6/10/77	13/10/77	18/10/77	2/11/77	16/11/77	17/11/77	29/11/77	7/12/77	8/12/77
Trashed or Burnt	Burnt	Trashed	Trashed	Trashed	Trashed	Burnt	Trashed	Burnt	Trashed
Tons Cane/h	240,8	186,4	183,7	171,6	188,5	204,2	178,1	220,4	175,2
Tons Fibre/h	34,8	31,9	30,9	30,7	31,6	31,2	29,4	33,3	29,8
Tons Imb./h	69,6	86,9	93,2	94,0	76,1	88,1	91,5	87,0	75,4
Net duration of run (h)	5,57	5,70	6,63	6,83	7,58	6,98	6,87	6,08	7,53
Pol % Cane (Dac)	13,57	12,48	12,90	12,08	12,46	13,06	12,16	13,05	12,46
Fibre % Cane (Dac)	14,47	17,13	16,83	17,87	16,75	15,26	16,52	15,12	17,01
Brix % Cane (Dac)	16,00	14,94	15,44	14,45	14,75	15,31	14,75	15,34	15,00
Non Pol % (Dac)	2,43	2,46	2,54	2,37	2,29	2,25	3,25	2,29	2,54
Insol. Solids in M.J. % Cane	0,39	0,60	0,78	0,67	0,60	0,57	0,78	0,58	0,61
Trash % Cane	11,6	12,7	13,0	12,5	11,9	5,0	13,6	8,1	12,9
Tops % Cane	1,5	2,2	2,3	2,0	1,7	1,5	3,0	2,4	2,4
Ash % Cane	0,82	1,25	1,05	1,13	1,22	1,02	1,00	1,12	0,92
Pol % Bag.	1,61	1,40	1,41	1,29	1,26	1,43	1,25	1,36	1,31
Brix % Bag.	3,17	2,81	3,34	2,76	2,98	2,96	2,83	2,98	2,94
Fibre % Bag.	43,98	43,56	44,62	42,23	45,66	44,08	42,12	39,26	38,77
Moisture % Bag.	52,85	53,63	52,04	55,01	51,36	53,00	55,05	57,76	58,24
Ash % Bag.	2,11	2,27	1,68	1,72	1,59	1,21	1,31	1,71	1,17
Extraction (Dac)	96,20	95,74	96,09	95,65	96,42	96,34	96,13	96,15	95,55
Corrected Reduced Extraction	95,66	96,18	96,31	96,35	96,71	96,12	96,37	95,86	95,97
Imb. % Fibre	212	254	302	306	241	285	327	272	262
Tons Cane/Hilo	21,95	18,81	20,43	18,42	19,78	21,09	20,16	22,69	19,15