THE EFFECT OF TRASH ON THE OPERATION AND PERFORMANCE OF A RAW SUGAR FACTORY

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KEYWORDS: Extraneous Matter, Trash, Throughput, Recovery, Purity.

Abstract

SINCE 1949, a considerable amount of work has been published describing the results of factory experiments to measure the effect of trash in cane on factory throughput and performance. This paper has attempted to review all of those studies, summarise the results and draw conclusions from them. Trash in cane reduces the crushing rate for both milling trains and diffusers, although the mechanisms for the reduction in rate are different. Considerably more experimental work has been conducted on milling trains and it is clear that the major effect of trash in reducing crushing rate results from its higher fibre content. In diffusers, it is expected that the lower bulk density of trash is responsible for reducing throughput. The effect of trash on extraction is not clear but is small. There is a stronger effect on bagasse moisture content and it is reasonably clear that trash increases bagasse moisture content. There is no doubt that trash reduces juice purity. While it has not been measured experimentally, it is reasonably certain that this result implies lower sugar production and higher molasses production.

Introduction

There is a worldwide trend away from burning cane prior to harvest. One reason for this trend is that countries are placing environmental restrictions on the burning of sugarcane. Another reason for the trend is that the trash that would be burnt has value in applications such as boiler fuel. The harvesting task is more difficult with green cane than with burnt cane and the level of trash in green cane is invariably higher than in burnt cane. While it is well appreciated that the higher trash content in cane has a substantial impact on the operation and performance of a raw sugar factory, the size of that impact is not well defined.

The impact of trash has been a significant issue for the sugar industry for many years. The financial impact of trash has been estimated by many authors including Birkett (1965), Humbert (1974), Clarke *et al.* (1988), Allen and McDonald (1999) and Kent *et al.* (2003a). Rein (2005) presented a broad analysis of the effect of trash and tops on the operation and performance of a sugar mill.

Economic analyses of the effect of trash rely on good experimental data. This paper aims to provide a comprehensive review of published factory experiments where the effect of trash on the factory has been measured and attempts to provide a useful summary of the experimental results. While this paper focuses on factory experiments, it is recognised that there is also a considerable body of work where the effect of trash has been studied in laboratory-size mills. Coleman (1959), Nichols (1968), Arceneaux and Davidson (1973), Legendre and Irvine (1973), Hemaide *et al.* (1977) and Fogliata *et al.* (1977) present results from investigations with laboratory-size mills but these investigations are not included in this paper's review.

Factory experiments

South African Sugar Technologists' Association (1949) described the earliest known factory experiment to determine the effect of trash on the factory. Single tests were conducted for both whole cane (green and uncleaned) and burnt cane. The whole cane was cut and crushed on the same day.

The burnt cane was cut three days after burning and processed four days after burning. The tests were conducted on cane in adjacent fields using cane of similar age and ratoon. Each test was conducted over about five hours.

Sloane and Rhodes (1972) described single test comparisons of green cane against burnt cane at five factories. For each factory, the cane for the two tests was sourced from adjacent areas. Each test was conducted over 10 to 12 hours. These tests have not been considered further in this paper because of the presence of cane cleaners and the uncertainty over the trash levels that entered the factories.

Scott (1977) described experiments at two factories. At Felixton factory, 56 tests were conducted. At Mount Edgecombe factory, 18 tests were conducted. Unlike the experiments described by South African Sugar Technologists' Association (1949) and Sloane and Rhodes (1972), Scott's experiments did not involve tests from single fields. Instead, cane consignments of the same variety and similar trash content were combined to make a sufficiently large cane supply for each test. The duration of each test was about one hour.

Lamusse and Munsamy (1979) described two experiments at one factory consisting of pairs of tests where each pair consisted of a comparison of burnt cane against green cane. One experiment consisted of nine pairs of tests with the cane processed by a milling train.

The second experiment consisted of five pairs of tests with the cane processed by a cane diffuser. This second experiment is the only identified experiment involving a diffuser. Like Scott (1977), the approach for building a sufficiently large cane supply involved combining appropriate cane consignments. The cane supplies for the two tests in each pair were processed within 24 hours of each other, with each test of about six hours duration.

De Beer *et al.* (1989) and Reid and Lionnet (1989) described a series of four tests at one factory where comparisons were made between burnt cane and whole cane and also between topped cane and untopped cane. Purchase *et al.* (1990) also described these experiments. The cane supplies were taken from three fields and processed at two weekly intervals. In all cases, the cane was processed four days after harvest. The duration of each test was about one hour.

Kent *et al.* (1999) reported on an experiment at Mossman factory involving five pairs of tests where the cane supplies for a pair of tests were sourced from the same field. The level of trash was varied by adjusting both the harvester ground speed and the speed of the harvester extractor fans. The duration of each test was about one hour.

Kent *et al.* (2003b) described a further two experiments at Mossman factory. The first experiment, conducted in 1999, involved two pairs of tests with each test lasting three days. The experiment attempted to control the harvesting parameters for all district harvesters so that the effect on sugar production and sugar quality could be measured.

Unfortunately, controlling the entire harvesting fleet proved difficult and a substantial difference in trash content was not achieved. The second experiment, conducted in 2000, was similar to that reported by Kent *et al.* (1999) and involved a further five pairs of tests of duration about one hour.

The measured effect of trash

The definition of trash

The reported trash measurements did not all use the same definition of trash. It is understood that the trash measurements of Scott (1977), Lamusse and Munsamy (1979) and de Beer *et al.* (1989) included only the leaf from the stalk in the definition of trash. Kent *et al.* (1999) and Kent *et*

al. (2003b) also included green leaf from the tops in the definition of trash. South African Sugar Technologists' Association (1949) did not report trash contents for their experiment but did report other trash measurements made during the same season. An estimate of the trash content, including green leaf, was made.

Crushing rate

All experiments assessed the effect of trash on crushing rate. The range of crushing rates varied from 16 t/h to 380 t/h. To provide a meaningful comparison between the different factories, the percentage change in crushing rate with trash content was calculated.

Table 1 presents the percentage decrease in crushing rate for a 1% increase in trash % cane for the factories using milling trains. The average result was a 2.3% decrease in crushing rate for a 1% increase in trash % cane.

Table 1—Percentage decrease in crushing rate for a 1% increase in trash % cane for factories using milling trains.

Test series	Decrease in crushing rate	Comments
SASTA (1949)	2.3	Assumed trash content
Scott (1977) at Felixton	2.2	
Scott (1977) at Mount Edgecombe	3.0	
Lamusse and Munsamy (1979)	2.3	
Reid and Lionnet (1989)	4.0	
Kent (1999)	1.6	
Kent (2003b) 1999 series	3.7	Small difference in trash content
Kent (2003b) 2000 series	2.0	
Median	2.3	

From the results for the cane diffuser presented by Lamusse and Munsamy (1979), there was a 3.1% decrease in processing rate for a 1% increase in trash % cane.

Fibre rate

All experiments also reported cane fibre content measurements or fibre rate measurements, enabling the effect of trash content on fibre rate to be assessed. Table 2 presents the percentage decrease in fibre rate for a 1% increase in trash % cane for the factories using milling trains. The average result was a 0.4% decrease in fibre rate for a 1% increase in trash % cane.

Table 2—Percentage decrease in fibre rate for a 1% increase in trash % cane for factories using milling trains.

Test series	Decrease in fibre rate	Comments
SASTA (1949)	1.3	Assumed trash content
Scott (1977) at Felixton	0.7	
Scott (1977) at Mount Edgecombe	2.4	
Lamusse and Munsamy (1979)	0.0	
Reid and Lionnet (1989)	–0.9	
Kent (1999)	–1.2	
Kent (2003b) 1999 series	1.2	Small difference in trash content
Kent (2003b) 2000 series	–0.4	
Median	0.4	

Scott (1977), Kent *et al.* (1999) and Kent *et al.* (2003b) presented some statistical analysis of the results. While the confidence limits reported by Scott (1977) indicate that his results were statistically significant, the analysis of variance results reported by Kent *et al.* (1999) and Kent *et al.* (2003b) showed no statistically significant result.

Scott (1977) analysed considerably more test results than Kent *et al.* which may partly explain the difference. What cannot be easily explained is why some results indicate an increase in fibre rate with trash content and other results indicate a decrease in fibre rate with trash content.

In summary, it seems reasonable to assume that trash does not substantially change the fibre rate. Trash, however, does increase the fibre content in the cane which causes the change in crushing rate.

Extraction

All experiments except those reported by Scott (1977) provided total pol extraction results. Table 3 presents the decrease in total pol extraction for a 1% increase in trash % cane for the factories using milling trains. The average result was a 0.1 unit decrease in extraction for a 1% increase in trash % cane.

Table 3—Decrease in total pol extraction for a 1% increase in trash % cane for factories using milling trains.

Test series	Decrease in extraction	Comments
SASTA (1949)	0.09	Assumed trash content
Lamusse and Munsamy (1979)	0.10	
Reid and Lionnet (1989)	0.13	
Kent (1999)	–0.06	
Kent (2003b) 1999 series	0.56	Small difference in trash content
Kent (2003b) 2000 series	–0.02	
Median	0.10	

Kent *et al.* (1999) and Kent *et al.* (2003b) reported that their results were not statistically significant. No statistical analysis was reported for any of the other results.

From the results for the cane diffuser presented by Lamusse and Munsamy (1979), there was a 0.01 unit decrease in extraction for a 1% increase in trash % cane.

Bagasse moisture content

All experiments except those reported by Scott (1977) and Reid and Lionnet (1989) provided bagasse moisture content results. Table 4 presents the increase in bagasse moisture content for a 1% increase in trash % cane for the factories using milling trains. The average result was a 0.12 unit increase in bagasse moisture content for a 1% increase in trash % cane.

Table 4—Increase in bagasse moisture content for a 1% increase in trash % cane for factories using milling trains.

Test series	Increase in moisture content	Comments
SASTA (1949)	–0.02	Assumed trash content
Lamusse and Munsamy (1979)	–0.06	
Kent (1999)	0.12	
Kent (2003b) 1999 series	0.54	Small difference in trash content
Kent (2003b) 2000 series	0.35	
Median	0.12	

While Kent *et al.* (1999) reported that their result was not statistically significant, Kent *et al.* (2003b) found that the effect of trash on bagasse moisture content was statistically significant. No statistical analysis was reported for any of the other results.

From the results for the cane diffuser presented by Lamusse and Munsamy (1979), there was a 0.15 unit increase in bagasse moisture content for a 1% increase in trash % cane.

Mixed juice purity

Because of the relatively short nature of the comparative tests, it was not possible to directly measure an effect of trash on sugar production. While Kent *et al.* (2003b) attempted to measure the effect on sugar production in their 1999 tests, the small difference in trash content gave little confidence in the sugar production results.

The best available indicator of the likely changes in sugar production from most experiments was mixed juice purity. Mixed juice purity can be used in a recovery formula to estimate sugar recovery, providing estimates of sugar and molasses production. All experiments except for Scott (1977) and Lamusse and Munsamy (1979) reported mixed juice purity.

Table 5 presents the decrease in mixed juice purity for a 1% increase in trash % cane for the factories using milling trains. The average result was a 0.30 unit decrease in mixed juice purity for a 1% increase in trash % cane.

Table 5—Decrease in mixed juice purity for a 1% increase in trash % cane for factories using milling trains.

Test series	Decrease in purity	Comments
SASTA (1949)	0.05	Assumed trash content
Reid and Lionnet (1989)	0.43	
Kent (1999)	0.30	
Kent (2003b) 1999 series	6.00	Small difference in trash content
Kent (2003b) 2000 series	0.27	
Median	0.30	

Both Kent *et al.* (1999) and Kent *et al.* (2003b) reported that the effect of trash on mixed juice purity was statistically significant. No statistical analysis was reported for any of the other results.

Further analysis

No factory experiments reported factory measurements downstream of mixed juice. Reid and Lionnet (1989) and Kent *et al.* (2003b) both, however, further processed the factory mixed juice samples in the laboratory in order to do further analysis. These extra analyses are not reported in this paper.

Conclusions

A considerable amount of factory experimentation into the effect of trash in cane on factory throughput and performance has been conducted. There is no doubt that trash decreases crushing rate. The effect in milling trains is mainly a fibre effect. Trash inflates the fibre content in cane. The effect of trash on fibre rate has not been conclusively established and, in the absence of further data, it is considered best to assume that the fibre rate is not affected by trash in cane.

The effect of trash on throughput in a cane diffuser appears to be of similar magnitude to the effect in a milling train although the cause is somewhat different. It is expected that the reduction in rate through a diffuser is caused by the change in bulk density of the cane which has not been discussed in this paper. Sloane and Rhodes (1972), Lamusse and Munsamy (1979), de Beer *et al.* (1989) and Kent *et al.* (2003b) all provided data to show the reduction in bulk density with increasing trash content.

The effect of trash on extraction is not clear. No statistically significant results have been obtained although, on average, a small reduction in extraction with increasing trash content has been measured. While there has been some inconsistency in the reported results on the effect of trash on bagasse moisture content, it is considered probable that trash does increase the bagasse moisture content. It is clear that trash reduces mixed juice purity.

The consequence of this reduction in purity is a reduction in sugar production and an increase in molasses production. It has not been possible to measure these changes but available evidence and theory points to this result.

This paper has summarised and commented on the published factory experiments that measure the effect of trash on factory operation and performance. It is hoped that this paper, along with Rein (2005), will be a useful reference for technologists who wish to assess the economic impact of trash in their own region.

REFERENCES

Allen, C.J. and McDonald, A.C. (1999). The real cost of extraneous matter in the Australian Industry. Int. Sugar J., 101(1209): 447–449.

Arceneaux, G. and Davidson, L.G. (1973). Some effects of trash in cane on milling results. Sugar J., 35(10): 33–41.

Birkett, L.S. (1965). The influence of tops and trash on the economics of sugar production. Proc. Int. Soc. Sugar Cane Technol., 12: 1636–1642.

Clarke, W.B., Player, M.R. and Weiss, G.H. (1988). Effect of extraneous matter on millers' and growers' costs. Proc. Aust. Soc. Sugar Cane Technol., 10: 39–46.

Coleman, R.E. (1959). Quality of harvested cane effected by trash and topping. Sugar J., 22(12): 9–11.

De Beer, A.G., Boast, M.M.W. and Worlock, B. (1989). The agricultural consequences of harvesting sugarcane containing various amounts of tops and trash. Proc. S. Afr. Sugar Technol. Ass., 63: 107–110.

Fogliata, F.A., Ayala, H.G., Delfini, A. and Limpias, D.B. (1977). Effects of increasing quantities of trash on sugarcane milling. Proc. Int. Soc. Sugar Cane Technol., 16: 2971–2981.

Hemaide, S. El-Nasr A., Sabed, G. El-Kareem and El-Badani, A.A. (1977). Effect of green and dry trash on cane and milling qualities. Proc. Int. Soc. Sugar Cane Technol., 16: 2485–2492.

Humbert, R.P. (1974). Improving burns with desiccants as an aid to mechanical harvesting. Proc. Int. Soc. Sugar Cane Technol., 15: 1065–1073.

Kent, G.A., Allen, W.J., Hoare, C.P. and Dixon, T.F. (1999). The effect of extraneous matter on factory throughput and performance. Proc. Aust. Soc. Sugar Cane Technol., 21: 38–43.

Kent, G.A., Hoare, C.P. and Allen, W.J. (2003a). The economics of trash reduction in the Mossman district. Proc. Aust. Soc. Sugar Cane Technol. (CD-ROM), 25: 6p.

Kent, G.A., Hoare, C.P., Miller, K.F. and Allen, W.J. (2003b). Harvest and factory data to assist in evaluating the effect of extraneous matter on sugar production costs and revenues. Proc. Aust. Soc. Sugar Cane Technol. (CD-ROM), 25: 15p.

Lamusse, J.P. and Munsamy, S. (1979). Extraneous matter in cane and its effect on the extraction plant. Proc. S. Afr. Sugar Technol. Ass., 53: 84–89.

Legendre, B.L. and Irvine, J.E. (1973). Some effects of cane trash on milling quality of sugar cane. Proc. Amer. Soc. Sugar Cane Technol., 3(NS): 167–173.

Nichols, E.F. (1968). Sugar cane trash and milling losses. Proc. Conf. Sugar Tech. Assoc. Trinidad and Tobago, 2: 67–70.

Purchase, B.S., Lionnet, G.R.E., Reid, M.J., Wienese, A. and de Beer, A.G. (1990). Options for and implications of increasing the supply of bagasse by industry. Proc. Conf. Sugar Process. Res. Inst., 229–243.

Reid, M.J. and Lionnet, G.R.E. (1989). The effect of tops and trash on cane milling based on trials at Maidstone. Proc. S. Afr. Sugar Technol. Ass., 63: 3–6.

Rein, P.W. (2005). The effect of green cane harvesting on a sugar mill. Proc. Int. Soc. Sugar Cane Technol., 25: 513–520.

Scott, R.P. (1977). The limitations imposed on crushing rate by tops and trash. Proc. S. Afr. Sugar Technol. Ass., 51: 164–166.

Sloane, G.E. and Rhodes, L.J. (1972). A comparison of the processing of burned and unburned sugarcane. Hawaiian Planters' Record, 58: 173–181.

South African Sugar Technologists' Association (1949). Report of the Trash Investigation Committee. Proc. S. Afr. Sugar Technol. Ass., 23: 48–52.

EFFETS DE LA PAILLE SUR L'OPERATION ET LA PERFORMANCE DE LA SUCRERIE DE CANNES

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MOTS CLEFS: Pailles, Bouts Blancs, Récupération, Pureté, Débits.

Résume

LA LITTERATURE sucrière contient un grand nombre de papiers décrivant les effets de la paille sur la performance des sucreries; la plupart des expériences ont été faites a l'échelle de la sucrerie. Ce papier va reprendre les travaux publies a partir de 1949; on va résumer les résultats et donner des conclusions. La paille réduit le tonnage heure aux moulins et a la diffusion; les mécanismes de ces réductions sont différents. On a travaille beaucoup avec les moulins et on a pu conclure que la réduction se fait a cause de l'augmentation de la fibre. Aux diffuseurs c'est la réduction de la densité grâce a la paille qui réduit le débit de canne. L'effet de la paille sur l'extraction n'est pas bien établi, mais plutôt faible. L'effet sur l'humidité de la bagasse est plus marque; la paille augmente l'humidité. Il n'y a pas de doute que la paille réduit la pureté du jus. On est raisonnablement certain que la présence de la paille va réduire la production du sucre et augmenter celle de la mêlasse.

EL EFECTO DE LOS RESIDUOS DE COSECHA EN LA OPERACIÓN Y COMPORTAMIENTO DE UN INGENIO DE AZÚCAR CRUDO

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Resumen

DESDE 1949 se han publicado considerable cantidad de trabajos que describen los resultados de experimentos fabriles para medir el efecto de la materia extraña de la caña en la capacidad y eficiencia de las fábricas. Este artículo intenta revisar esos estudios, resumirlos y extraer conclusiones a partir de sus resultados. La materia extraña en la caña reduce la tasa de molienda tanto para trenes de molienda como para difusores, aunque los mecanismos para esas reducciones son diferentes. Ha habido considerablemente mas trabajo experimental en trenes de molinos y es claro que el mayor efecto de la materia extraña sobre la tasa de molienda es consecuencia del incremento en la cantidad de fibra. En difusores se considera que la menor densidad aparente de la materia extraña es responsable de la reducción. El efecto de la materia extraña en la extracción no es claro pero es pequeño. Hay un fuerte efecto sobre la humedad del bagazo y está razonablemente claro que la materia extraña incrementa el contenido de humedad del bagazo. No hay duda que la materia extraña reduce la pureza del jugo. Si bien el efecto no ha sido medido experimentalmente, es razonablemente cierto que esta condición implica menor producción de azúcar y mayor producción de mieles.