THE LIMITATIONS IMPOSED ON CRUSHING RATE BY TOPS AND TRASH

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Abstract

Experiments were conducted at two milling factories to quantify the effect on cane throughputs when crushing tops and trash with the sugar cane. The presence of trash was found to be highly significant in reducing crushing rate and fibre throughput. Tops, on the other hand, appeared to have no influence. Regression equations are presented showing the effect of fibre % cane, trash % cane and tops % cane on crushing rate. The effect of different cane varieties was also studied.

Introduction

One of the factors accepted as being rate limiting when determining the cane throughput of a milling tandem is the amount of fibre to be handled. The magnitude of the fibre % cane value is an integral function of the crushing rate calculation and hence the measurement of fibre throughputs or loadings is of the utmost importance. It is, however, the total fibre in cane that is considered; no distinction being made between the fibre contributed by clean cane and the fibre contributed by extraneous matter in the form of tops and trash. Notable authors such as G. P. Meade[9], have advised that "adhering leaves and the immature tops of stalks that remain because of careless harvesting, increase the quantity of fibre that must be passed through the mills".

Thus the fibre % total cane value is highly dependent upon cane quality and this is immediately apparent on an examination of Table 1.

It has been shown[2] that a linear relationship exists between fibre % cane and trash % cane, and fibre % trash. Keller and Schaffer[6] reported that a unit increase in the trash % cane content increased fibre % cane by 2,75%.

TABLE 1
Typical fibre contents of cane, tops and trash[7]

Fibre %	Maximum	Minimum	Mean	Standard Deviation
Clean stalk	16,7	10,9	12,8	±1,3
Tops	31,2	10,7	16,6	±4,1
Trash	82,7	28,3	58,6	±13,4

TABLE 2
Comparison of extraneous matter contents

Country	Method	Mud and Sand	Tops %	Trash %	Total
Taiwan[8] 1975	Hand cut	1,32	2,41	2,44	6,17
	Machine harvested	4,21	6,43	5,45	16,09
Cuba[3] 1970	Hand cut	0,09	1,25	1,41	2,75
	Machine harvested	0,22	7,60	4,55	12,37
South Africa[10] 1976 (Huletts Mills)	Burnt	Not	2,67	3,07	5,74
	Trashed	measured	2,22	8,80	11,02

The introduction of mechanical harvesting results in a deterioration in cane quality as measured by the degree of extraneous matter accompanying the cane.

Further, the effect of trash on crushing rate was studied in South Africa[1] almost 30 years ago and found to impose severe limitations on throughput. On a factory trial, a crushing rate of 90 tch was obtained with clean cane whilst only 55 tch was obtained when crushing cane containing 10,66% trash.

With the installation of articulated grabs at all Huletts mills during 1975 for the purpose of monitoring cane quality[5], it was decided to conduct an investigation under modern conditions to quantify the influence of tops and trash on crushing rate.

Investigational procedure

Towards the end of the 1975/76 crushing season (November to January) a number of tests were conducted on the No. 1 (i.e. 110 tch) tandem at Felixton. The initial procedure involved accumulating cane of a given variety and similar extraneous matter content (e.g. very trashy) up to a sufficient test mass (80 to 120 tons) prior to the test.

The test consignment was then fed to the main carrier continuously and the SICB electronic cane tracker[4] used to plot the position of the "head" and "tail" of the consignment through to the feed chute of the first mill. The time taken by this known cane mass to be crushed, as shown by the tracker, was recorded. (For all tests, the crushing setpoint was the same; the mill merely being allowed to feed itself so that the required height of cane was maintained in the feed chute.)

The consignment was sampled in the usual manner for the DAC determination by the Central Board and analysed by their laboratory. The fibre % cane value for that particular consignment was thus obtained. At the same time, samples of this consignment were withdrawn from the main carrier (before the knives) by means of the grab sampler at the rate of one sample per 15–20 tons. These samples were then analysed according to the standard test method for tops and trash[5].

It should be pointed out that a subsequent appraisal by the Central Board[7] has revealed that the grab method exhibits no evidence of bias in attaining a cane sample. In addition, the imprecision of the method rapidly diminishes the greater the number of samples taken per consignment. With four to five samples removed per consignment and averaged, the margin of inexactitude as regards the tops % and trash % cane values in this investigation can be said to be small.

A further series of tests was later repeated at Mount Edgecombe, the only difference being that no varietal effect was studied.

Results and discussion

(i) *Felixton*

It is well known that different varieties of cane possess differing qualities of "fibre type". For example NCo 376 can be said to be very fibrous whereas N55/805 possesses fibre more of a pithy nature. The investigation was, therefore, designed so that the influence of cane variety on crushing rate might also be examined by only crushing cane of one particular varietal type per test. The three most common varieties for that area, NCo 376, N55/805 and NCo 310 were studied. The data accumulated appears in Table 3.

Using statistical techniques it was found that both fibre % cane and trash % cane are highly correlated with tons cane per hour for all the varieties studied. This is to be expected in the light of the high fibre in trash. Tops % cane did not correlate and thus does not appear to impose a practical limitation on crushing rate. This is explained by the fact that tops have a low fibre content which is of a soft nature and easily crushed. The relevant correlation coefficients appear in Table 4.

Regression analysis yielded the following equations predicting the effect of fibre % cane on crushing rate split by cane variety.

Tons Cane per Hour =
- 205,3 — 5,2 fibre % cane — NCo 376
- 199,0 — 5,2 fibre % cane — NCo 310
- 195,5 — 5,2 fibre % cane — N55/805
- 203,3 — 5,3 fibre % cane — combined

Using the method of analysis of variance it was found that the differences due to cane variety did not affect the slope of the lines but merely the intercept.

Confidence limits of 95% for the reduction in crushing rate per unit increase in fibre % cane are 5,2 ± 1,3 tons cane per hour or a reduction of 2,56 ± 0,64%.

It is similarly possible to calculate the effect of trash % cane.

Tons Cane per Hour =
- 138,2 — 3,0 trash % cane — NCo 376
- 133,4 — 3,0 trash % cane — NCo 310
- 127,7 — 3,0 trash % cane — N55/805
- 134,3 — 3,0 trash % cane — combined

TABLE 3
Summary of Felixton crushing rate data

		CANE VARIETY			
		376	805	310	Combined
Fibre % cane	Mean	16,6	16,8	17,7	17,0
	Std. Dev.	2,64	2,05	2,28	2,40
	Range	14,6–26,9	13,4–19,7	13,0–20,9	13,0–26,9
Trash % cane	Mean	6,4	6,4	8,7	7,1
	Std. Dev.	4,15	3,83	4,21	4,16
	Range	1,7–14,4	1,4–13,6	2,8–15,8	1,4–15,8
Tops % cane	Mean	5,1	3,8	4,3	4,5
	Std. Dev.	2,16	1,63	2,71	2,26
	Range	1,9–9,3	1,2–6,8	1,0–10,7	1,0–10,7
Tons cane per hour	Mean	118,8	107,1	108,4	112,7
	Std. Dev.	19,60	16,36	12,69	17,54
	Range	83,5–149,4	90,1–125,7	86,1–141,8	83,5–149,4
Number of tests		25	14	17	56

TABLE 4
Correlation coefficients — Felixton

		CANE VARIETY			
		376	805	310	Combined
Fibre % cane	Trash % cane	0,67†	0,81†	0,42	0,64†
	Tops % cane	0,04	–0,16	–0,06	–0,05
	Tons cane/hour	–0,66†	–0,86†	–0,83†	–0,73†
	Tons fibre/hour	0,17	0,10	0,32	0,14
Trash % cane	Tons cane/hour	–0,78†	–0,88†	–0,57*	–0,72†
	Tons fibre/hour	–0,32	–0,11	–0,35	–0,28*
Tops % cane	Tons cane/hour	0,01	0,14	–0,08	0,07

* Significant between 5% and 1% level.
† Significant beyond 0,1% level.

This effect is represented graphically in Figure 1. Confidence limits of 95% for the reduction in crushing rate per unit increase in trash % cane are 3,0 ± 0,8 tons cane per hour or a reduction of 2,23 ± 0,60%.

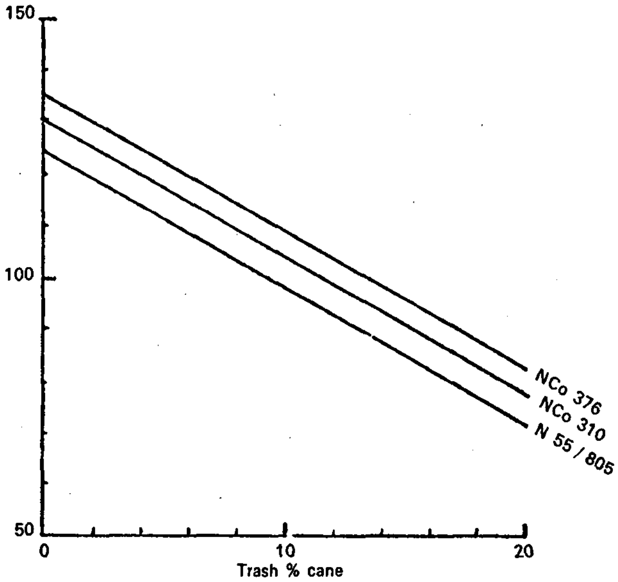

FIGURE 1 Relation between crushing rate and trash % cane.

Crushing rate may also be expressed in terms of fibre throughput. Only trash % cane correlated with tons fibre per hour and the regression equation predicting the influence of trash % cane, irrespective of variety, is given by:

Tons fibre per Hour — 19,81 — 0,13 trash % cane.

Confidence limits of 95% for the reduction in fibre rate per unit increase in trash % cane are 0,13 ± 0,12 tons cane per hour or a reduction of 0,66 ± 0,60 %.

Further interpretation of the data through the use of multiple linear regressions allowed the effect of tops on crushing rate to be evaluated after the masking effect of trash had been removed.

Tons Cane per Hour =
- 132,4 — 3,2 trash % cane + 1,3 tops % cane — NCo 376
- 129,2 — 3,2 trash % cane + 1,3 tops % cane — NCo 310
- 123,7 — 3,2 trash % cane + 1,3 tops % cane — N55/805
- 127,8 — 3,2 trash % cane + 1,7 tops % cane — combined

The coefficients of both variables are significant at the 5% level. The partial correlation coefficient between tons cane per hour and tops % cane is 0,32 which was also significant at the 5% level. The partial correlation is a measure of the correlation between crushing rate and tops % cane when the effect of trash % cane on the crushing rate is removed. It might appear that tops increase crushing rate but this is not the case. The maximum crushing rate has been reduced to take account of the presence of trash.

(ii) *Mount Edgecombe*

In order to ascertain that these findings were not peculiar to Felixton, a further series of tests was conducted at Mount Edgecombe during September through to November, 1976.

No varietal effect was studied as a result of difficulties in controlling and co-ordinating cane supplies (for all practical purposes the varietal effect is small and may be safely disregarded). A summary of the data appears in Table 5.

In general, close agreement was found with the Felixton results although correlations were not as significant as a result of only 18 tests being completed satisfactorily.

The significant parameters were again found to be fibre % cane and trash % cane as shown in Table 6.

Again using regression analysis, the equations predicting the effect of fibre % cane and trash % cane on crushing rate are:

$$\text{Tons Cane per Hour} = \begin{cases} 480{,}3 - 17{,}0 \text{ fibre \% cane} \\ 263{,}2 - 8{,}0 \text{ trash \% cane} \end{cases}$$

Confidence limits of 95% for the reduction in crushing rate per unit increase in trash % cane are 8,0 ± 0,51 or a reduction of 3,0 ± 0,19%. A very similar result to that obtained at Felixton. Further, as for Felixton, only trash % cane correlated with tons fibre per hour, clearly indicating that the effect of trash fibre on reducing throughput is over and above that of cane fibre.

Tons fibre per Hour = 38,83 — 0,95 trash % cane.

Confidence limits of 95% for the reduction in fibre throughput per unit increase in trash % cane are 0,95 ± 0,65 or a reduction of 2,45 ± 1,6%. Finally, the multiple regression equation for the combined effect of tops and trash on crushing rate showed similar trends to those obtained at Felixton.

Tons Cane per Hour = 254,4 — 7,5 trash % cane + 2,2 tops % cane.

Conclusion

It has been shown through tests carried out at two milling factories that extraneous matter imposes limitations on crushing rate. The extent of this effect lies between a 2,2% and 3,0% reduction per 1% presence by weight of trash % cane; the more conservative estimate of 2,2% being the more statistically correct figure. In neither investigation did tops exhibit any adverse influence on cane throughput rates, although being a material with volume, it will obviously occupy space in the tandem.

It is also alarming to note that the fibre quality of trash is of a more deleterious nature than cane fibre and imposes limitations on fibre throughputs over and above that of the cane fibre. That is not to say that cane fibre does not reduce fibre throughputs but rather, in the conditions found in this investigation, trash with its large variability imposed the more significant hindrance on fibre throughputs.

It is immediately apparent that a reduction in the amount of trash accompanying the cane to the mill will not only result in a lowering of transport costs because of the reduced weight to be conveyed but also a reduction in the length of the crushing season becomes possible as a consequence of the decreased mass of cane to be crushed and the faster crushing rate.

For example, assuming a factory crushes 1 000 000 tons of cane per season of 40 weeks at an average of 140 hours open per week. Assume also that the average trash % cane to be handled is 6% (i.e. 940 000 Tons clean cane and 60 000 Tons trash).

$$\text{Crushing Rate} = \frac{1\,000\,000}{40 \times 140} = 178{,}5 \text{ tch}$$

Now, if the trash % cane is reduced from 6% to 5% the expected increased crushing rate will be:

$$178{,}5 \times 1{,}022 = 182{,}4 \text{ tch.}$$

If the same clean cane tonnage is handled, the gross cane to be milled will amount to 989 500 tons (i.e. 940 000 + 49 500 tons). The new season length will be:

$$\frac{989\,500}{182{,}4 \times 140} = 38{,}7 \text{ Weeks}$$

Thus, for a unit reduction in trash % cane there is a reduction in crushing season length in this case of 1,3 weeks or 3,25%. The improvement in cane quality will thus prove beneficial to the industry as a whole.

TABLE 5

Summary of Mount Edgecombe crushing rate data

	Mean	Standard Deviation	Range
Fibre % cane . . .	15,46	1,16	13,5–17,9
Trash % cane . .	5,70	2,64	1,5–10,9
Tops % cane . . .	2,70	2,02	1,1–9,1
Tons cane per hour .	217,5	34,09	158,7–272,0

TABLE 6

Correlation coefficients — Mount Edgecombe

		Correlation Coefficient
Fibre % cane	Trash % cane	0,30
	Tops % cane	−0,32
	Tons cane/hour	−0,58*
	Tons fibre/hour	−0,14
Trash % cane	Tons cane/hour	−0,62†
	Tons fibre/hour	−0,59†
Tops % cane	Tons cane/hour	0,31

* Significant between 2% and 1% level.

† Significant beyond 1% level.

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