THE EFFECT OF CANE QUALITY ON FACTORY PERFORMANCE – HOW IMPORTANT IS IT?

By E. J. BUCHANAN
Technical Adviser, South African Cane Growers' Association

Abstract

An analysis is presented of statistical trends in cane quality and yields over the past 25 seasons. It is shown that the increased returns as a result of increased sugar yields (exclusive of factory performance) more than offset the cost of producing and processing the increased cane yield in spite of the fact that cane quality has decreased. This conclusion is not applicable to extraneous matter. However, there is evidence that the processing of tops (excluding leaves) could be economically advantageous in certain circumstances. This requires more detailed investigation. The presence of leaves and sand is undesirable except when their separation is prohibitively costly. The economics and practicality of their separation in the field, at reloading points and at the factory requires investigation.

Introduction

If factory performance is defined by any of the technological yardsticks the answer to the question posed in the title is clearly in the affirmative. However, if the performance is gauged in terms of profitability then the effect of cane quality, when all its implications are considered, is less obvious. This applies in particular if the subject is approached from the point of view of a mill crushing its own estate cane. In the South African sugar industry the total proceeds accruing to the whole industry, less levies, is distributed between the grower and miller groups in proportion to their established costs and return on capital employed. The analogy of a milling company crushing its own estate cane is therefore appropriate as the basis for optimistation.

The object of this paper is to draw to the attention of technologists that there exists for any given set of circumstances an optimum cane quality consistent with maximum overall profitability and that the highest quality cane rarely achieves this in practice. The case of the individual miller whose parochial economics diverge from estimated industrial trends could provide an exception which is beyond the scope of this paper.

Trends in cane quality

The correlations of sucrose % cane, fibre % cane and purity of mixed juice against time are shown in Table 2. During the past 25 years sucrose % cane has diminished at a steady rate of 0,029 per annum. Understandably, this trend is viewed with some consternation in certain quarters particularly if forecasts are made on past trends. This is compounded by the observation that mixed juice purity has diminished at a rate of 0,038 per annum. However, some compensation may be gained from the fact that fibre % cane has diminished at the rate of 0,053 per annum (when correction is made for the recent addition of suspended solids).

The area under cane has increased enormously from 176 293 to 337 813 hectares during the past 25 years. This includes the opening to cane of new areas in the midlands and Transvaal. These changes must be borne in mind in comparing long-term industrial averages. However, the trends have applied fairly consistently in each of the three ten-year periods so that the expansion would not appear to detract in any large degree from their significance.

TABLE 1
25 years statistical data

Year	Rain mm	Yield erc/ha	Sucrose % cane	Fibre % cane	Purity (Mixed juice)	Age Years
1	1 101	3,651	14,19	15,80	86,40	2,01
2	780	2,925	13,33	16,29	84,92	2,05
3	892	3,377	13,87	16,10	86,25	2,10
4	802	3,196	13,93	16,31	85,61	2,35
5	1 045	3,584	13,34	16,03	85,86	2,29
6	1 200	3,852	13,87	15,74	85,96	2,29
7	974	3,406	13,35	15,81	85,49	2,28
8	1 242	3,684	13,11	15,38	85,10	2,34
9	1 281	4,199	13,12	15,92	84,46	2,21
10	846	3,818	13,66	15,92	85,52	2,25
11	906	3,620	13,69	15,22	85,63	2,51
12	1 095	3,970	13,75	14,52	86,04	2,68
13	866	4,480	13,29	15,49	83,36	2,14
14	973	4,670	13,55	15,50	85,30	2,06
15	1 039	4,423	13,90	15,38	85,52	2,19
16	737	2,860	12,99	15,57	84,22	2,75
17	995	4,948	13,72	15,09	85,06	1,95
18	982	5,531	12,92	15,01	83,41	1,68
19	764	4,640	13,11	15,32	83,60	1,82
20	1 011	4,946	12,88	15,03	84,25	1,79
21	787	4,326	13,61	15,34	84,99	2,00
22	1 226	5,884	12,97	14,82	85,14	1,74
23	1 117	6,165	13,26	14,82	85,16*	1,75
24	798	5,424	13,08	14,79*	84,16*	1,79
25	1 129	5,643	13,08	15,01*	83,51*	1,80

* corrected for recent analytical changes

TABLE 2

Time trends in cane quality

From 1950-51 to 1974-75:

$S = -0{,}0287n + 13{,}7964$ $(r = -0{,}5646^{**})$ . . . (1)

$F = -0{,}526n + 16{,}1398$ $(r = -0{,}7971^{***})$ . . . (2)

$P = -0{,}0764n + 85{,}9903$ $(r = -0{,}6234^{***})$ . . . (3)

Trends in yield

The data in Table 3 shows that yields have increased steadily over the same period at an annual rate of 0,106 tons erc per hectare under cane. During the period the "age" of cane (empirically determined by dividing area under cane by area cut each season) has steadily decreased at 0,021 of a year per annum. While this is the result of a deliberate policy aimed at increasing yields it could be an exaggeration to attribute the full increase in yield observed in equation (4) of Table 3 to this single expedient. It is a difficult task to determine the precise degree of productivity improvement which could be fairly attributed to the gradual decrease in age and in the absence of any better alternative equation (6) of Table 3 has been derived. This separates the yield increase into two categories, one based purely on time and the other on age. In this analysis "age" is simply the reciprocal of the fraction of area under cane which is cut each year. It will be noted that the regression coefficient against year number (n) has decreased from 0,106 in equation (4) to 0,077 in equation (6) with the inference that about one quarter of yield increase is attributable to reduced age of cutting (increased fraction cut of area under cane).

TABLE 3

Time trends in yield and age

From 1950-51 to 1974-75:

$y = 0{,}1057n + 0{,}0019\,(m-972) + 2{,}8928$ . . . . . (4)

$(R = 0{,}8920^{***}, t_n = 8{,}639, t_m = 3{,}465)$

$a = -0{,}02081n + 2{,}3833$ $(r = -0{,}5271^{**})$ . . . . (5)

$y = 0{,}0767n - 1{,}3892a + 0{,}0017\,(m-972) + 0{,}62081$ . . (6)

$(R = 0{,}9636^{***}, t_n = 8{,}782, t_m = 4{,}982, t_r = -6{,}261)$

Economic balance

Statistics indicate that while cane quality has diminished, yields have increased. The extent to which these trends are related is not certain. However, it is known that cane has been cut at a progressively younger age, as confirmed by equation (5) and that this would typically result in the quality trends shown in Table 2. Equation (6) provides an estimate of the yield increase attributable to age reduction. When compared against equation (4) it may be inferred that one quarter of the progressive yield increase is attributable to cutting younger cane. If this were offset against the complete decline in cane quality a very conservative balance would result. On the other hand there could also be a case for offsetting the decline in cane quality against the whole of the increase in yield. Both of these cases are examined.

The decline in cane quality as indicated by the regression equations in Table 2 is represented in Table 4.

TABLE 4

Decline in cane quality computed from Table 2

Year number	0	25
Season	1949–50	1974–75
Sucrose % cane	13,80	13,08
Fibre % cane	16,14	14,82
Purity mixed juice	85,99	84,08
Extracted non-pol % cane	2,14	2,35
erc % cane	11,80	11,02
Tons cane/ton erc	8,47	9,07
Sucrose/fibre ratio	0,86	0,88

$(E = 0{,}9870S - 0{,}5687N^{*} - 0{,}0372F)$

* *extracted N*

The latter data indicate an increase from 8,47 to 9,07 tons cane per ton erc over 25 years. This amounts to 0,024 per annum. Therefore to produce 1,8 million tons sugar an additional amount of 43 200 tons cane is harvested and processed each year due to decline in cane quality. From Table 4 it will be appreciated that since the sucrose/fibre ratio has increased from 0,86 to 0,88, while the non-pol level has only marginally increased, the decline in sucrose or erc content has been mainly the result of increased water content. Under these circumstances the additional milling cost per ton sugar involves evaporator and back-end equipment. A marginal processing cost would seem justified for the increased cane tonnage. The growing costs for the increased cane weight are estimated in Table 5 and the combined costs amount to R3,80 per ton additional cane. On 43 200 tons this amounts to R164 160 per annum.

TABLE 5

Cost per additional ton cane

Cutting cost (average)	0,95
Estimated transport (part marginal)	0,90
Infield and levies (marginal)	0,15
Fertilizer (average)	1,30
Marginal milling	0,50
Total	R3,80

The above costs must be offset against the net value of increased erc yields based on Table 3. We have two choices as shown in Table 6. In the first case the increased yield produces 34 881 tons erc per annum requiring the processing of an additiinal 316 371 tons cane. The cost to the industry of milling this cane should not be in excess of the marginal cost since it represents only 2 per cent increase. For this reason the costs in Table 5 will apply again. The total cost is R1 202 210. To this we may add the cost of producing and processing additional cane caused by the drop in quality giving R1 202 210 + R164 160 = R1 366 370.

TABLE 6

Value of increased yield

Case 1: Full value of increased yield	
Increase in tons erc/ha per annum ex equation (4)	= 0,1057
Hectares under cane	= 330 000
Increase in erc production, tons	= 34 881
Cane/erc ratio	= 9,07
Tons additional cane	= 316 371
Case 2: Value of yield increases attributable to age reduction	
Annual decrease in age, years equation (5)	= 0,0208
erc yield increase per year reduction in age, equation (6)	= 1,3892
erc yield increase, tons/ha per annum	= 0,0289
Hectares under cane	= 330 000
Increase in erc, tons	= 9 537
Cane/erc ratio	= 9,07
Tons additional cane	= 86 501

However, since the impurity level has increased each year as shown in Table 4 an additional amount of molasses is produced. Furthermore, the additional cane yield will also produce additional molasses. Using the data in Table 4 these two new molasses sources produce 760 and 11 073 tons molasses respectively totalling 11 833. At a net estimated return of R20 this amounts to R236 660 per annum. The cost of producing and processing the additional cane then reduces to R1 129 710 which must be offset by net sugar sales on 34 881 tons erc (or sugar). The additional sugar must therefore have a minimum net return of R32,39 per ton.

In the second case shown in Table 6 only the yield increase statistically attributable to age reduction has been taken to balance the reduction in cane quality. The yield increase is equivalent to 9 537 tons erc and 86 501 tons cane. At R3,80 per ton the marginal costs amount to R328 704 + R164 160 = R492 864. From this we may deduct marginal molasses net returns on 760 + 3 028 = 3 788 tons molasses amounting to R75 760. The residual cost is R417 104 which must be offset by net sales of 9 537 tons erc (or sugar). The minimum net price is therefore R43,74 per ton.

The profit from additional sugar yield at an ex factory price of R250 per ton sugar on marginal sales including the molasses revenue as above and deducting the costs also shown above are R7 590 240 in Case 1 and R1 967 146 in Case 2. These amounts would accrue to the industry as a whole.

Extraneous matter

Within the scope of the above analysis yield is more important than cane quality. However this does not necessarily apply to the extraneous matter aspect of cane quality since in this category fibre and impurity could increase without an increase in yield to offset the additional costs. It is for this reason that yield has been defined in terms of "tons erc per hectare".

In spite of this it is quite evident that the removal of extraneous matter can in some respects become expensive and in such circumstances a high level of cane cleanliness may become uneconomical. On the other hand should this be allowed to get out of control then the use of cane laundries may be inevitable. Sloane *et al*[2] have indicated that cane cleaning equipment has limited efficiency except at extremely high levels of extraneous matter and that sugar losses during cleaning are high. Combining this with high installed and operating costs would suggest that cane laundries are only justified as a last resort in the face of excessive extraneous matter such as would result from the operation of certain types of harvesting and loading equipment.

The problem does not arise to the same degree in the case of hand cutting, particularly if cane is burnt prior to harvesting. For example, Birkett[1] has shown that under a given set of circumstances the pretax profits of an estate crushing its own cane were related as follows:

(*a*) Gross cane (with tops and trash) . = 100,0
(*b*) Gross cane minus trash (with tops) = 116,9
(*c*) Clean cane (no tops or trash) . . = 109,9
(*d*) Clean cane to produce same amount of sugar as in (*a*) . . . . = 114,5

This indicates that the greatest profitability is derived from the milling of gross cane less trash; clean cane to produce the same amount of sugar as from gross cane is slightly less profitable. This advantage may be secondary to the need to produce more sugar when factory capacity for a given season length is limiting. However, if cane supply is limiting then it would be expedient to crush more tops in order to take advantage of marginal sugar and molasses production at no field cost.

While there may be some justification for leaving the top of the cane stalk intact the processing of leaf material should be avoided unless the cost of its removal is prohibitive. The same applies to other forms of extraneous material such as sand. The removal of leaf and sand may be achieved by:

(*a*) Selecting mechanical equipment for harvesting and loading which minimises leaf and sand as in Australia,
(*b*) Removal in cane cleaning centres at reloading points as in Cuba, or
(*c*) Removal at cane cleaning centres attached to factories such as in the U.S.A., etc.

While (*a*) may be the intuitive choice under flatland mechanisation in ideal conditions, the practicality and economy of the alternatives should be examined, particularly in view of their extensive use in overseas sugar industries.

The latter discussion has been included simply to draw attention to the fact that extraneous matter is an entirely separate subject to the inherent quality of the cane stalk and that the economics and method of removal require objective investigation. It is a far easier step to advocate blindly the complete removal of extraneous matter but this could possibly lead to loss of profits in the long run.

Discussion

It has been shown that provided the statistical trend of increasing yield continues then the accompanying decline in cane quality is justified on an economic basis. The annual increase in yield indicated by statistics is estimated to produce an additional R7,5 million in profits to the whole industry after deducting the field and factory costs for additional cane and costs due to processing lower quality cane. A more conservative estimate is made if only the portion of yield increase which is found to be statistically attributable to declining age of cane at cutting is balanced against the costs. This amounts to R2,0 million. In either case it is evident that yield increase has justified the accompanying decline in cane quality on the economic balance.

Conclusions

1. From statistical trends in cane quality and yield there is economic support for the reduction in cane quality provided yields continue to increase.
2. While the relative rates at which the two variables change must be closely screened it is evident that cane quality in itself should not be maximised to the exclusion of yield.
3. The extraneous matter aspect of cane quality must be excluded from the above conclusions. However, it is evident that under some circumstances the non-leaf portion of the tops can be processed to economic advantage. This aspect should be subjected to more detailed analysis.
4. Leaf and sand should be avoided, if they can be separated economically. The economics and practicability of such separation whether in the field at reloading points or at the factory should be subjected to objective investigation.

REFERENCES

1. Birkett, L. S. (1965). The influence of tops and trash on the economics of sugar production ISSCT Proc **12**: 1636-1641.
2. Sloane, G. E., *et al* (1971). Dry versus Wet cane cleaning at Laupahoehoe Sugar Company ISSCT Proc **14**: 1393-1404.

Nomenclature

E = estimated recoverable crystal % cane
F = fibre % cane
N = non-pol % cane (extracted)
P = purity mixed juice
R = multiple correlation coefficient
S = sucrose (pol) % cane
a = empirical age of cane, years
m = rainfall previous May to June, mm
n = year number, (1950-1 = 1)
t = t value
r = simple correlation coefficient
y = yield, tons erc/ha under cane