CHANGES IN CANE YIELD OF IRRIGATED VARIETY NCo 376 DUE TO SEASON AND THEIR IMPLICATIONS WHEN EVALUATING FIELD PERFORMANCE

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Abstract

Cane yield data from some Zimbabwe and Swaziland estates are presented and discussed. It is concluded that the yield of variety NCo 376 when harvested at the age of 12 months declines markedly and in a defined and predictable pattern associated with the month of harvest. This implies that the age-corrected measure of yield expressed as tons/hectare/month (t/ha/m) which also varies with age at harvest can be misleading as a measure of crop performance.

Since performance evaluation should relate actual yield to some standard, it is proposed that this be expressed in terms of the equivalent yield if the crop were harvested at 12 months of age in April/May. Using data from Triangle, correction factors appropriate to age and month of harvest were developed. These provide a simple, practical measure of field performance that has been termed the "corrected t cane/ha/month" or COTCHM for short. Various applications of this parameter are outlined.

While it is accepted that performance assessment should ideally be in terms of sucrose yield, the amount of millable cane is often easier, and sufficiently accurate to use for field management purposes.

Introduction

Seasonal variations in the yields of both cane and sucrose produced under irrigation in Zimbabwe and Swaziland have been observed commercially and in trials (Cackett and Rampf[1], Gosnell and Koenig[2], Lonsdale and Gosnell[3], Figures 1 and 2). Cackett and Rampf in Zimbabwe noted the marked decline in cane yield through the harvest season and explained that the high yields obtained from April to June were the result of optimum summer growing conditions coinciding with the period of rapid stalk elongation, whereas the poorer yields obtained when cane was harvested in summer reflected the restriction on growth imposed by low winter temperatures. The sucrose content of the cane, however, generally peaked in July/August.

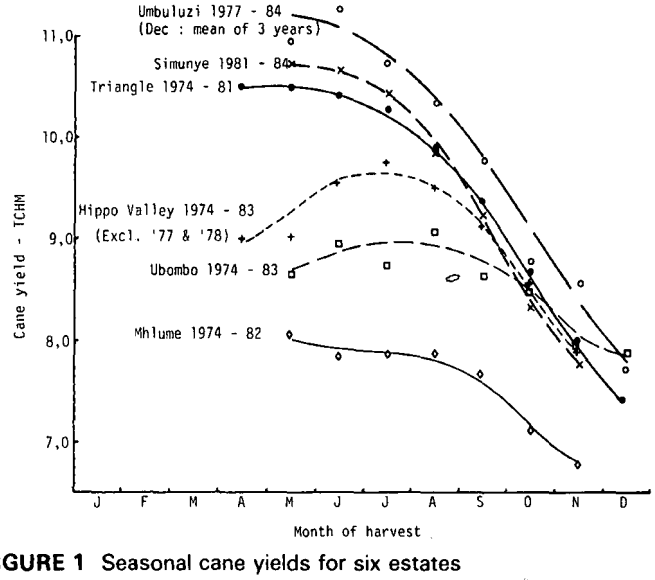

FIGURE 1 Seasonal cane yields for six estates

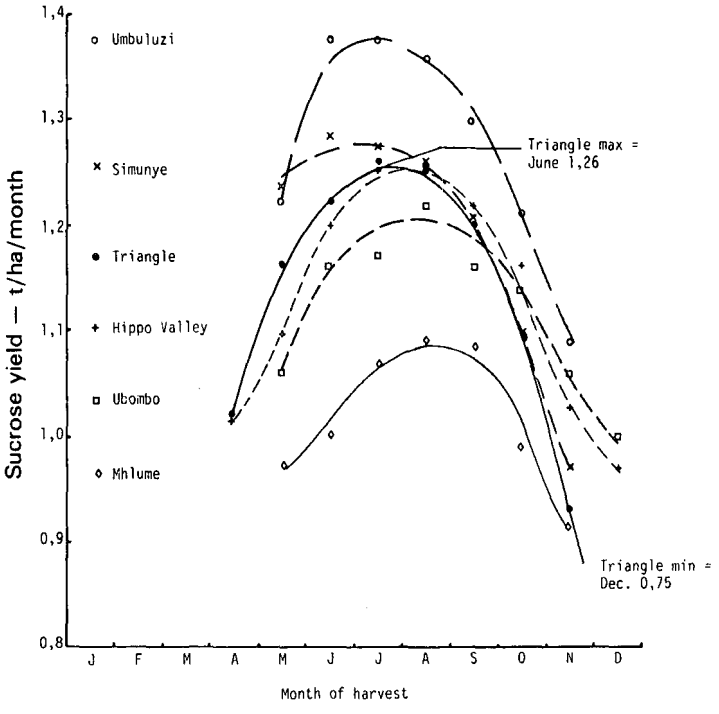

FIGURE 2 Estate seasonal sucrose yields

Since relative crop performance changes markedly through the season, the usual age-corrected measure of yield, t/ha/month, can be misleading. At Triangle, for example, a field cut in December and yielding 8,0 t cane/ha/month (TCHM) actually outperforms a field cut in April and yielding 10,5 TCHM (Figure 3).

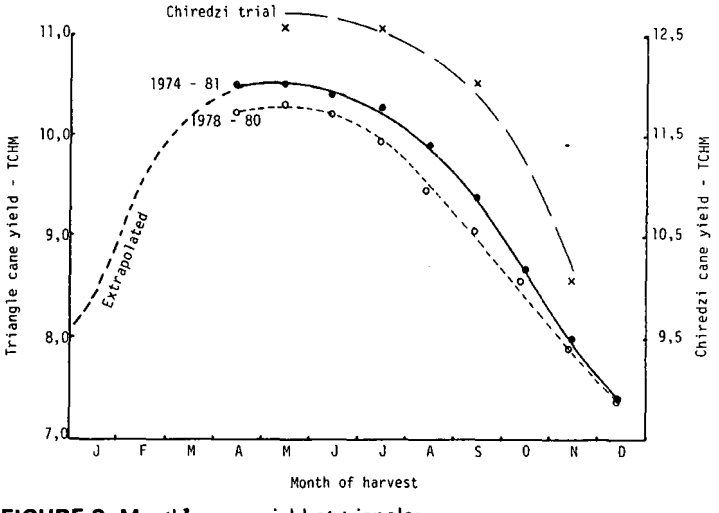

FIGURE 3 Monthly cane yield at triangle:
(i) over 8 years (1974–80)
(ii) over 3 atypical years (1978–81)
Yield of 12,0 month old NCo 376 and NCo 310 in a trial at Chiredzi (Lonsdale and Gosnell[2] 1975)

For field management purposes a measure of performance that relates yield to season would therefore be valuable. The problem is to establish the pattern of crop performance associated with climatic growth conditions, since other factors such as varieties and soil type will also modify yields.

It is suggested that the cane yield curves for Triangle, Simunye and Umbuluzi closely represent the pattern of the relative performance of 12 months old NCo 376 in Zimbabwe and Swaziland. The age of the crop also affects relative performance, and a method is proposed for relating actual yield to that of 12 month old cane.

While crop performance should ideally be measured in terms of sucrose, it has generally been found to be more convenient for field management purposes to use the amount of millable cane per hectare. This is certainly true in the context of this paper since estates vary widely in their accuracy and type of field sucrose records. The latter may be expressed as pol, sucrose, ERS or ERC, and historical records are often unavailable. Arguments to justify the use of cane yields include:

- cane and sucrose yields are closely related
- the grower has more control over cane yield than cane quality
- field conditions generally affect cane yield more than cane quality
- growers usually relate more readily to cane rather than sucrose yields.

Yield performance is therefore discussed in terms of millable cane although sucrose and sugar yields are given in Figure 2.

Method

Yield data were collected from various estates in Swaziland and Zimbabwe to examine the pattern of seasonal yield.

In order to study the relationship between estate yields and season, other factors such as age at harvest need to be reasonably constant through the season, and the data should relate to one variety. Triangle, Simunye and Umbuluzi estates were selected because their relatively high yields were likely to approach the climatic potential. Furthermore, detailed data analysis and selection was possible, eg only fields in which the soils were average or above average were selected, thus avoiding bias due to crops on poor soils being harvested selectively late in the season.

TABLE 1

Average cane yields by month of harvest over 8 years at Triangle, and correction factors to express cane yields as the April-harvested equivalent.

	Yield - tons cane/ha/month (TCHM)								
Year	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1974	10,3	10,6	10,5	10,4	10,0	9,0	8,6	8,0	7,6
1975	10,7	10,3	10,1	10,3	10,4	9,8	8,7	8,2	7,4
1976	11,0	11,0	10,9	10,5	10,5	9,8	9,1	8,4	7,8
1977	10,4	10,2	9,9	10,1	9,5	9,0	8,2	7,5	7,1
1978	(10,4)*	10,4	10,3	9,7	9,0	8,7	8,5	7,5	6,8
1979	9,5	9,6	9,9	9,8	9,5	8,8	8,1	7,9	(6,7)*
1980	10,8	10,8	10,5	10,3	9,8	9,5	9,2	8,3	8,0
1981	10,9	11,4	11,0	10,9	10,7	10,2	9,2	8,1	7,7
Mean	10,5	10,5	10,4	10,3	9,9	9,4	8,7	8,0	7,4
S E ±	0,51	0,55	0,42	0,39	0,58	0,55	0,43	0,34	0,48
C V %	4,9	5,2	4,0	3,8	5,9	5,9	4,9	4,3	6,5
Correction factors	1,00	1,00	1,01	1,02	1,06	1,12	1,21	1,31	1,42

* No cane was cut in April 1978 or Dec 1979. Respective TCHM's were derived from the relationship to April and Dec yields over the remaining 7 years.

The yield patterns on these estates are given in Figure 1. Salient features of the estates appear in Appendix 1. At Triangle, with 99% NCo 376, only fields carried over from one season to the next were excluded owing to their age and poor performance. Cane harvested in April had been carried over in three years, the amount being no more than 30% a year. The inclusion of these yields would have markedly depressed April crop performance. The other two estates had no carry-over cane, and only data for NCo 376 was selected. Some exceptionally low yielding Simunye fields with poor furrow irrigation designs were also excluded, but they were included once the management had been rectified.

The uniformity of yield decline, together with the low SE's and CV's at Triangle (Figures 1 and 4, Table 1), confirm that the same pattern of yield decline occurred every year despite annual variations in growing conditions.

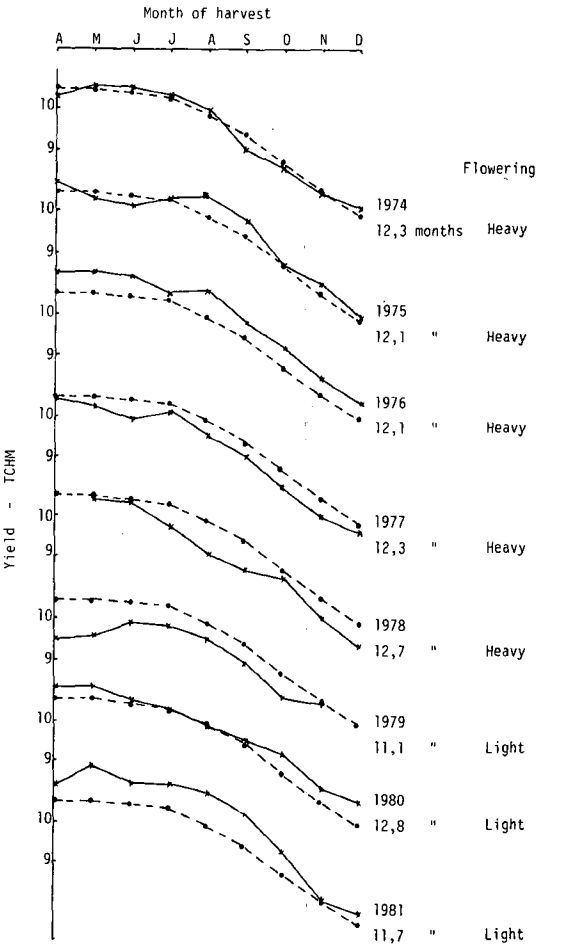

FIGURE 4 Annual variation of monthly cane yield from the 8 year mean (dotted line) at Triangle, plus mean annual age, and flowering intensity.

The consistent pattern of declining yields as the season advanced was confirmed in a trial conducted by Lonsdale and Gosnell[3] at Chiredzi (Figure 2). The Chiredzi trial included both NCo 376 and NCo 310, but the authors note that the seasonal fluctuations were similar for the two varieties.

A consistent bias in any factor affecting yields could have influenced the pattern. This is unlikely to have occurred at all three estates as well as in the Chiredzi trial, but various factors are discussed below, with special reference to Triangle.

Age

Age affects yield in terms of TCHM (Table 2) and Appendix 2 shows that there is a tendency for the crop to be cut at an older age late in the season, especially at Triangle. The varia-

tions were relatively small, however, particularly at Simunye and Umbuluzi, and their influence on the pattern should have been slight. Wide age fluctuations occurred at Triangle in 1978, 1979 and 1980 owing to changes in mill starting dates, but even in these three atypical years the pattern was not affected markedly. (Figures 3 and 4).

Variety

The Simunye, and Umbuluzi data were limited to NCo 376, and Triangle had only 1% of other varieties.

Soil type

If, for example, the crops on better soils were always cut early, this would enhance early yields. This was not the case, however. The crops grown on poor soils at Simunye are spread through the season. At Triangle, each of 26 sections harvest daily, so that a range of soil conditions is likely to be represented during each month of the season. Umbuluzi's good soils produce particularly high yields, but the pattern remains the same as that on other estates. (Figure 1).

Irrigation

Consistent inability of an irrigation scheme to meet the high crop water requirements in summer would depress early season yields. The slightly depressed early yields at Triangle relative to the other two estates may reflect water shortages due to power cuts in some years, but otherwise irrigation is considered to have been of a high standard, and unlikely to have affected yields.

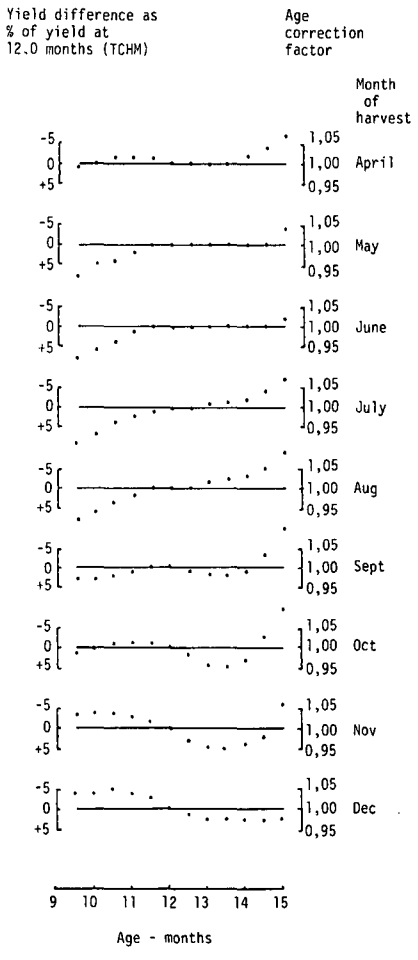

FIGURE 5 Effect of age of crop on yield and the associated age correction factors at Triangle.

TABLE 2

Effect of crop age on yield of NCo 376 at Chiredzi (Lonsdale & Gosnell[3])

Yield Parameter	Month of Harvest	Age at harvest - months					
		10	12	14	16	17	18
Cane t/ha/month	May	14,6	12,6	-	-	-	11,4
	July	13,4	12,6	11,1	-	-	-
	September	12,2	12,0	11,3	10,0	-	-
	November	-	10,1	10,7	9,7	9,3	-
Sucrose t/ha/month	May	1,72	1,53	-	-	-	1,23
	July	1,91	1,89	1,67	-	-	-
	September	1,90	1,99	1,78	1,71	-	-
	November	-	1,58	1,66	1,56	1,48	-
Cane yield as % of yield at 12,0 months	May	116	100	-	-	-	90
	July	106	100	88	-	-	-
	September	102	100	94	83	-	-
	November	-	100	106	96	92	-

Flowering

This is known to depress late season yields, but the effect was not obvious in heavy flowering years at Triangle, and little flowering occurred at Simunye and Umbuluzi. The effects are therefore assumed to have been small. (Figure 4).

Lodging

This was generally light, occurring both early and late in the season, and was unlikely to have affected the pattern of yield variation.

Harvest conditions

Damage from harvesting in wet conditions during the higher rainfall months of November and December may have reduced yields in those months, but this generally affected only a minor proportion of the fields, and was unlikely to have markedly influenced yield. Figure 4 shows little variation from year to year, even though November and December were relatively dry in some years.

Plant cane

A preponderance of plant cane in any one year could have affected the results, but this is unlikely to have happened since TCHM yields of plant and ratoon cane were generally fairly similar at Triangle, and plant cane was harvested through the season, mostly between July and December.

The yield for Hippo Valley, Ubombo and Mhlume, where it was not possible to select data, show how factors other than season can have a marked effect (Figure 1). This was particularly so early in the season, when the best grown cane is likely to be most susceptible to other limiting factors, and at Mhlume, where the soils are very poor.

Different varieties, carry-over cane and poor soils are the main factors likely to have affected the patterns of yield decline on these estates, whilst at Mhlume the problem of poor soils was compounded by the difficulty of irrigating sufficiently frequently in summer.

The effect of a single factor was demonstrated at Simunye in 1984, when 40% of the cane harvested in May was N52/219. This variety represented only 7% of the estate, and its exclusion raised the average for May from 8,6 to 9,9 TCHM.

Once standard yields have been established for each month of the year, performance may be evaluated by expressing yield as a percentage of the standard. Although the yield decline curves for Triangle, Simunye and Umbuluzi estates were similar in shape, absolute levels varied, with Umbuluzi consistently highest, probably as a result of better soils (Figure 1).

Even the exceptionally high yields at Chiredzi followed a similar pattern (Figure 2).

It was therefore decided to express yields in terms of the April/May harvested equivalent, this being the period of highest cane yields. This was achieved by using appropriate correction factors, obtained as outlined in Table 1 to account for month of harvest, in Appendix 3 to account for crop age in months, and in Table 3 to account for both of these factors. Since the concept was first developed and applied at Triangle, that estate's yield data were used to prepare Table 3. The result has been termed the "corrected t cane/ha/month" or "COTCHM".

TABLE 3

Combined correction factors: to express cane yield of NCo 376 as 12,0 month old, April-harvested equivalent.

Age-months	Month of harvest								
	A	M	J	J	A	S	O	N	D
9,5	0,99	0,92	0,93	0,93	0,96	1,09	1,20	1,36	1,48
10,0	1,00	0,95	0,95	0,95	1,00	1,09	1,21	1,36	1,48
10,5	1,01	0,96	0,97	0,98	1,02	1,10	1,22	1,36	1,49
11,0	1,01	0,98	0,99	0,99	1,04	1,11	1,22	1,35	1,48
11,5	1,01	1,00	1,01	1,01	1,06	1,12	1,22	1,34	1,46
12,0	1,00	1,00	1,01	1,02	1,06	1,12	1,21	1,31	1,42
12,5	1,00	1,00	1,01	1,02	1,06	1,11	1,19	1,27	1,39
13,0	1,00	1,00	1,01	1,03	1,07	1,10	1,16	1,24	1,38
13,5	1,00	1,00	1,01	1,03	1,08	1,10	1,16	1,24	1,38
14,0	1,02	1,00	1,01	1,04	1,09	1,11	1,17	1,26	1,38
14,5	1,04	1,00	1,01	1,06	1,11	1,16	1,25	1,28	1,38
15,0	1,07	1,04	1,03	1,09	1,16	1,23	1,33	1,39	1,38

The factors are not necessarily very accurate, having been derived from a limited amount of field data. They are least reliable when the age of the crop varies more than 1,5 months from the 12,0 month standard. Furthermore, they relate only to ratoon cane and may differ for plant cane.

Discussion

This improved measure of yield performance is potentially a valuable management tool with practical, field level application.

Field performance graphs

Plotting COTCHM against crop stage establishes a picture of performance trends which is easy to interpret, being free of seasonal and age effects. This is of particular value where fields are harvested at different times each year, being affected not only by age but also by season.

Figure 6 is an example which serves to illustrate how actual cane yields may not reflect true performance.

Field performance potential

The performance of the crop in an individual field (Figure 6) can be assessed in relation to a standard yield.

Plough-out decisions

Replanting is the most expensive field operation and it is often done without full appreciation of the implications. The COTCHM concept allows this decision to be made rationally and objectively by establishing the increase in yield that is likely to result due to replanting (Figure 6). This increase will not only establish whether ploughing out is economically justified, but also the priority rating of each field in a plough-out programme.

After replanting, a crop is usually harvested at an age greater than that of subsequent ratoon crops. This will affect its actual yield, making COTCHM particular value in evaluating the benefits of ploughing out and replanting.

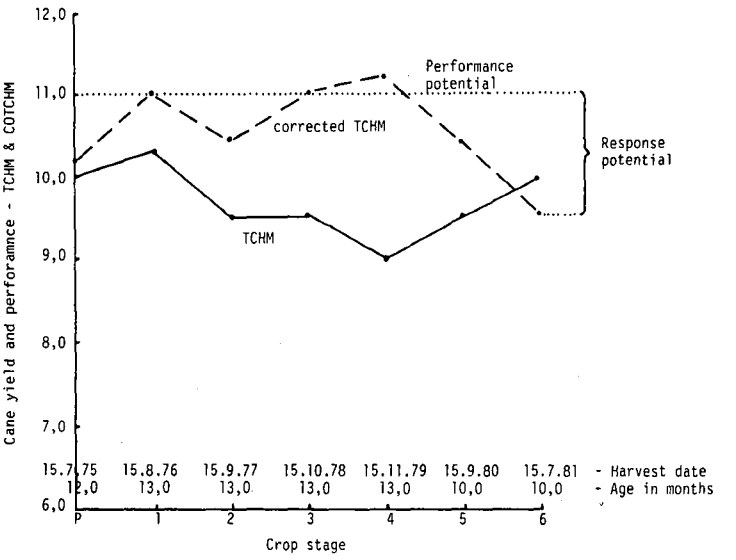

FIGURE 6 A field performance graph depicting the difference between TCHM and corrected TCHM (COTCHM).

Yield prediction

The past performance of the crop in a field (Figure 6) permits an objective prediction of yield in COTCHM to be made. The appropriate correction factor for the anticipated age and date of harvest can then be used to convert to TCHM and TCH thus:

(i) $$\frac{\textbf{Predicted COTCHM}}{\text{Correction factor}} = \text{TCHM}$$

(ii) **TCHM × predicted age** = TCH

The effect of age on yield is minor in comparison to the seasonal effect, being no more than 3% if it is within half a month of the 12,0 month standard (Appendix 2), and since the factors for the more divergent ages are suspect it could be argued that age should be ignored. However, since the age of the crop does frequently vary considerably, an accurate assessment of its effect should be made if possible.

Seasonal and age factors have been related to the date of harvesting rather than to the date of starting the ratoon crop. These are obviously the same for 12,0 month old cane, but either approach could be used, provided the correction factors are developed accordingly. Harvesting date was chosen since field yield data at Triangle are grouped according to the month of harvest.

Conclusion

The correction factors developed here are not necessarily very accurate, and they will be subject to annual variations in climate. Furthermore, they relate specifically to the Triangle estate and to NCo 376. It is nevertheless believed that they still provide a valuable means of evaluating crop performance even in Swaziland. The concept could easily be adapted to different situations and varieties. Other varieties could even be expressed as NCo 376 equivalent. The concept could also be applied to sucrose yield once reliable sucrose patterns have been established.

- The concept of expressing cane yield as the equivalent of 12,0 month old cane harvested in April/May as a standard provides an improved measure of field performance that rationally compensates for crop age and the marked effect that month of harvest has on yield. It has been called the "corrected t cane/ha/month" or COTCHM for short.
- This improved measure of performance is a potentially valuable management tool, especially at individual field level.

Acknowledgements

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APPENDIX 1

Salient estates features.

Estate	Approx ha under cane	Years Reviewed	% NCo 376 (Approx)	Mean monthly age	Soil Quality	Carry-over cane	Field data excluded for purposes of this paper	Comments
Triangle (Zimbabwe)	12 000	1974 - 81 (8)	99	12,1 Usual: ± 1 Exception: ± 2	Average	Frequent in early years	All carry-over	Irrigation: 60% o/head, 40% furrow. 1979 - poor yield year. Estate and records well known.
Simunye (Swaziland)	9 000	1982 - 84 (3)	80 - 85	11,9 (11,5 - 12,6)	Average	Nil	Other varieties and some very poor layout furrow irrigated fields.	Irrigation: 80% o/head, 20% furrow. Young estate 1982 first year of full production. Estate and records well known.
Umbuluzi (Swaziland)	1 100	1977 - 84 (8)	95	11,9 Usual ± 0,6 Exception ± 1	Above Average	Nil	Other varieties	Irrigation: 100% o/head. Adjacent to Simunye. Records examined in detail.
Hippo Valley (Zimbabwe)	8 000	1974 - 83 (Excluding 1977, 78) (8)	90	12,3 Wide variations of 10,5 - 16,0	Above Average	Occurred several years	All 1977 and 78 owing to exceptionally wide age variations and very poor performance.	Irrigation: 100% furrow. No data selection, except for 1977 and 78. Wide age fluctuations. Records not examined.
Ubombo (Swaziland)	7 500	1974 - 83 (10)	80	11,7 Usual: 11,3 - 12,4 Exception: 11,0 - 13,0	Average	Occurred occasionally	Nil.	Irrigation: 46% o/head. 54% furrow. No data selection. Problems meeting summer water demand. Records not examined.
Mhlume (Swaziland)	4 000	1974 - 82 (9)	60 - 80	13,0 1974 - 76: 14 approx 1978 - 79: 13 approx Rest: 12 approx	Poor (approx 50% Problem soils)	Frequent in early years.	Nil.	Irrigation: 30% o/head, 70% furrow. Difficulty meeting rapid irrigation cycles required for the low TAM soils. No data selection. Records not examined.

APPENDIX 2

Average monthly age of cane at Triangle, Simunye, and Umbuluzi, excluding carry-over cane

Month of Harvest	Age - months									Mean
	A	M	J	J	A	S	O	N	D	
1974	12,1	12,2	12,1	12,1	12,4	12,8	12,9	13,0	13,2	12,3
1975	12,7[1]	12,4	12,1	12,0	12,0	12,4	12,3	12,4	12,4	12,1
1976	12,1	11,9	11,9	12,1	12,1	12,0	12,7	12,7	12,8	12,1
Triangle 1977	12,7[1]	12,5	12,1	12,1	12,3	12,4	12,2	13,1	12,3	12,3
1978	-	12,9	13,0	12,7	13,0	13,1	13,2	12,5	12,2	12,7
1979	11,1	10,9	10,7	10,9	11,1	11,2	11,3	11,7	-	11,1
1980	11,8	11,8	11,9	12,0	12,6	12,7	13,3	13,9	14,0	12,8
1981	12,1	11,5	11,7	11,6	11,5	11,7	11,8	11,9	12,0	11,7
Mean	12,1	12,0	11,9	11,9	12,1	12,3	12,5	12,7	12,7	12,1
Simunye 1981 - 83	-	12,0	12,0	11,7	11,7	12,0	12,2	12,3	-	12,0
Umbuluzi '77 - 84	-	11,8	11,3	12,0	11,9	11,9	12,5	12,3	12,7[2]	12,0
Overall Mean	12,1	11,9	11,7	11,9	12,0	12,1	12,4	12,5	12,7	12,0

1 : Ages approximate
2 : Only 2 years data

APPENDIX 3

Age correction: factors to correct cane yields of NCo 376 at Triangle to 12,0 month of equivalent

Age (months)	Month of harvest								
	A	M	J	J	A	S	O	N	D
9,5	0,99	0,92	0,92	0,91	0,91	0,97	0,99	1,04	1,04
10,0	1,00	0,95	0,94	0,93	0,94	0,97	1,00	1,04	1,04
10,5	1,01	0,96	0,96	0,96	0,96	0,98	1,01	1,04	1,05
11,0	1,01	0,98	0,98	0,97	0,98	0,99	1,01	1,03	1,04
11,5	1,01	1,00	1,00	0,99	1,00	1,00	1,01	1,02	1,03
12,0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
12,5	1,00	1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,98
13,0	1,00	1,00	1,00	1,01	1,01	0,98	0,96	0,95	0,97
13,5	1,00	1,00	1,00	1,01	1,02	0,98	0,96	0,95	0,97
14,0	1,02	1,00	1,00	1,02	1,03	0,99	0,97	0,96	0,97
14,5	1,04	1,00	1,00	1,04	1,05	1,04	1,03	0,98	0,97
15,0	1,07	1,04	1,02	1,07	1,09	1,10	1,10	1,06	0,97