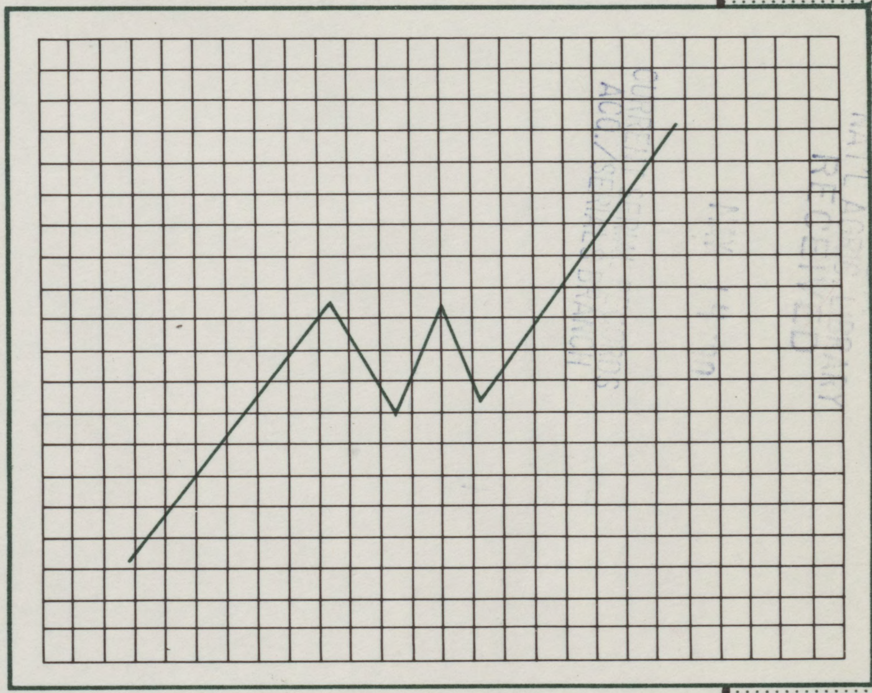

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CONSIDERATION OF THE SUGAR-CANE STUBBLE REPLACEMENT DECISION AT MHLUME, SWAZILAND

by J.N.S. Hill*

ABSTRACT

The decline in per hectare sugar-cane yields with increasing ratoons at Mhlume led to an investigation into various replant policies. Analysis of field history data from commercial fields identified distinctly different yield decline patterns for different land classes and the influence of fallowing and green manuring was also isolated. Net present value analyses of net benefit streams from yield models derived from these data have indicated the optimum stages (ratoon) at which replanting should occur.

INTRODUCTION

Workman, Scott & Nixon (1986) documented evidence to show that on certain soils at Mhlume cane yields decline rapidly with increasing ratoons. These authors showed that on a certain area of more than 1 000 hectares third ratoons produced only 79 % of plant cane yields. They commented further that "yields have improved in plant and first ratoon crops (over previous years) but then collapse faster, confirming that these poorer soils are indeed in a worse condition than previously.... high and regular input of organic matter is required to prevent their total loss."

This work initiated studies at Mhlume on fallowing and green manuring and some of the preliminary findings will be presented below. However, more detailed analysis of field history data has also been undertaken with a view to shedding light on the optimum ratoon life question. These results are presented first.

The stubble replacement decision in sugar-cane farming is one which has important financial implications for the farmer. Most farmers follow traditional ideas in this regard and a more scientific method using yield decline models and discounted cash flows should therefore improve the overall financial performance of the sugar farm.

METHODS

Yield data for Mhlume's commercial fields have been captured and recorded using the Mhlume (Swaziland) Sugar Company ICL 2904 mainframe computer system. Although records of yields are available on printout from 1976 to 1987, the present yield analysis has been restricted to the past eight seasons, 1980 to 1987, because prior to 1980 the age of cane at harvest was significantly greater than the present 11,6 months average. Replant analysis included data from the full 12-year period. Initially the stage of ratoon at which replanting was carried out was noted for all 126 blocks of cane at Mhlume (average block area under cane: 37,1 hectares). These were then arranged into separate land class categories (Nixon, Workman & Glendinning, 1986) and frequencies of ratoon stage replantings were noted.

Subsequently, three large samples of blocks representing the four major land classes found at Mhlume were separated and individual yields by ratoon were categorised.

Frequency of replanting, correlations and regressions on yield decline patterns and net present value analyses on net benefit streams from derived yield models were then considered for the various groups of data.

RESULTS

Frequency of replanting

The frequency of replanting by ratoon stage for all commercial fields, over the period 1976 to 1987 (12 years), is categorised by land class in Table 1. From these data it can be seen that three distinct groupings of fields can be made, with different average replant frequencies. These are group 1, consisting of land classes 1 and 2 (the most suitable soils for sugar-cane production), group 2, consisting of land class 4, and group 3, consisting of land classes 5, 6 and 7 (land class 7 is barely arable; these three classes are least suitable for sugar-cane production). In Figure 1 the frequency distributions by percentage are shown against the ratoon stage when replanting was undertaken.

It can be seen that group 1 soils (classes 1 and 2) show a wide flat curve with a peak which indicates that most replanting occurred at the sixth ratoon. Group 2 soils peak at the fourth ratoon and group 3 soils (poorest) show a sharp peak at the third ratoon.

Yield decline patterns

Analysis of all commercial field yields by ratoon for the eight seasons 1980 to 1987 reveals the average yield decline pattern shown in Fig. 2. A full set of data exists for yields between the plant cane stage and the fourth ratoon, which covers 90 % of the total area. Fewer data are available for the remaining,

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TABLE 1. Frequency of replantings at different ratoon stages for all Mhlume fields categorised by land class

Land class	Ratoon stage							
	1R	2R	3R	4R	5R	6R	7R	8R
1	0	1*	5	6	6	10	5	6
2	0	0	1	0	2	1	0	0
(1 + 2) %	0 %	2%	14 %	14 %	19 %	26 %	11 %	14 %
4	1	3	7	12	11	11	4	2
(4) %	2 %	6 %	14 %	24 %	22 %	21 %	8 %	3 %
5	0	1	1	2	1	1	0	0
6	1	15	32	30	4	9	4	0
7	0	7	15	7	2	2	1	2
(5 + 6 + 7) %	1 %	17 %	36 %	28 %	5 %	9 %	3 %	1 %
Total %	1 %	12 %	26 %	25 %	11 %	15 %	6 %	4 %

*The numbers in the table represent the number of fields replanted at the ratoon stage indicated in the column heading

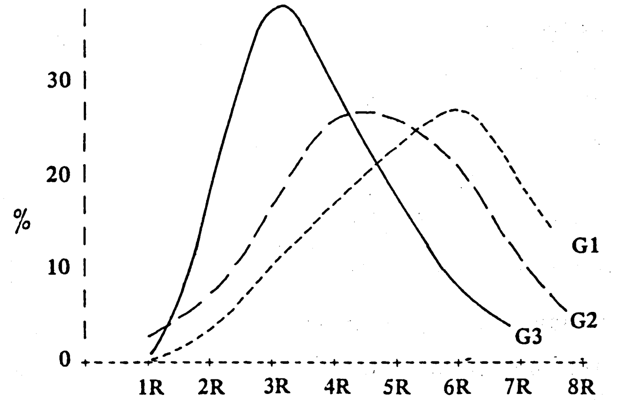

FIG. 1. Frequency distribution (%) of replanting by ratoon stage for three land class groupings at Mhlume

older ratoons. For the plant to the fourth ratoon stage the yield decline is virtually linear (correlation coefficient = -0,99) and the slope of the line is negative, 4,8 TCH (tons of cane per hectare) per ratoon.

Fig. 2 depicts the average yield decline at Mhlume. Of greater interest, however, are the yield decline patterns for the various land class groupings. A large sample of blocks was randomly selected from each category and their yield data were obtained from the field history files. These data are presented in Table 2. Correlation and regression analyses for each of the three land class groupings' yield by ratoon patterns were carried out. These are presented in Fig. 3.

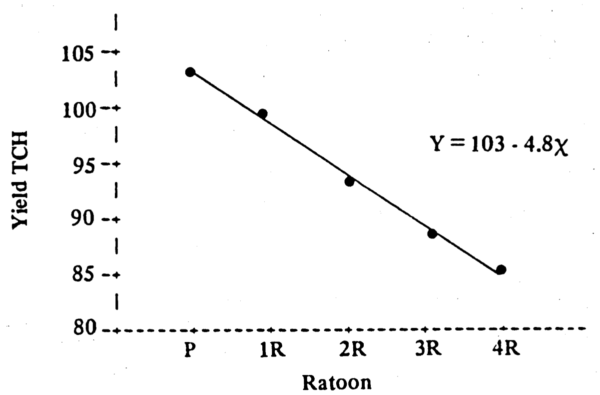

FIG. 2. Yield decline with increasing ratoon at Mhlume : 1980 - 1987

TABLE 2. Yields (TCH) by ratoon by land class at Mhlume Sugar Company (1980 - 1987)

Block	P	1R	2R	3R	4R	5R	6R	7R
Land class 1: sample area = 335 ha								
501	88	105	105	92	102	99	108	-
502	96	104	117	100	117	112	100	-
503	95	95	111	108	93	99	111	-
504	105	101	113	121	97	79	83	-
511	82	116	87	110	92	-	-	101
512	81	105	76	105	95	-	-	102
513	86	118	81	118	93	101	105	111
520	147	-	121	111	97	102	100	96
521	131	99	129	100	97	120	-	93
522	142	93	126	93	-	122	101	98
523	129	94	128	93	-	112	-	91
524	93	79	120	85	108	93	100	-
Mean	**106**	**101**	**109**	**102**	**101**	**103**	**101**	**99**
Land class 4: sample area = 532 ha								
212	132	97	113	110	106	119		
213	104	87	107	104	75	76		
214	128	134	134	120	104	98		
223	106	108	102	114	66	92		
225	101	103	126	72	101	114		
304	139	94	91	99	64	-		
305	98	109	94	76	73	69		
313	-	81	97	63	94	-		
321	98	73	86	94	84	52		
345	92	85	77	75	-	106		
411	96	70	73	96	84	69		
427	75	106	77	77	98	-		
433	91	98	89	-	-	-		
Mean	**107**	**97**	**95**	**92**	**88**	**90**		
Land classes 6 and 7: sample area = 626 ha								
202	125	85	87	76	-			
203	84	62	95	67	68			
204	130	105	93	75	79			
205	94	101	85	73	78			
207	107	97	71	75	-			
208	98	81	90	76	-			
301	97	97	84	76	-			
302	151	96	83	76	-			
303	96	85	90	76	-			
323	148	96	90	65	-			
326	128	103	85	63	74			
331	132	94	75	83	71			
404	94	93	75	88	42			
405	79	97	71	83	-			
Mean	**108**	**93**	**84**	**74**	**68**			
Overall mean	**107**	**97**	**96**	**89**	**86**			

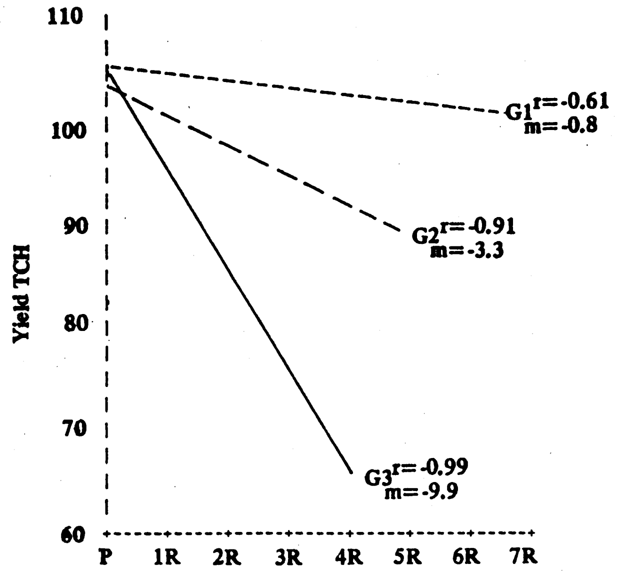

FIG. 3. Yield decline patterns by crop stage for three land class groupings at Mhlume

The correlation coefficients (r) are very high for each sample and the overall coefficient for the entire sample population was -0,97, with a corresponding regression coefficient (m) of -5,0. These are in close agreement with those found for all fields as shown in Fig. 2 and support the confidence with which the sample data may be used in subsequent analyses.

Net present value analyses (NPV)

The concept of discounting future benefit and cost streams is widely used in economic and financial analyses and has been explained by numerous authors (Irvin, 1984; Hill, 1985; and Hoekstra; 1976). In the interests of brevity in this paper, the lengthy tables of benefit and cost streams are not presented. Only the results of the analyses themselves are given. Benefit (income) and cost values used in this work are those obtained from Mhlume for the 1987/88 financial year and the analysis is presented in real terms. A 15% discount rate was selected to approximate a current interest rate on borrowed short-term capital.

The management information systems developed by Hill, Van Vuuren & Ellis (1988) were used to compute average costs for key farming operations. The assumption is made that sucrose percentage does not differ on different soil types since all the available data would suggest that this holds true at Mhlume. Furthermore it is assumed that operation costs do not differ significantly between land class groupings. The latter assumption may not be valid, but further work is required before this refinement of the analysis is possible.

In Table 3 the net present values (NPV) at 15% discount rate of the net benefit streams over a 30-year period for numerous alternative replant policies on each soil group are presented.

TABLE 3. NPV (15%) of net benefit streams (R/ha) from replanting various soil groups at different ratoon stages

	Soil group 1	Soil group 2	Soil group 3
Replant at ratoon: 2	11 793	11 388	9 970
Replant at ratoon: 3	12 663	12 026	9 999*
Replant at ratoon: 4	13 128	12 287	9 666
Replant at ratoon: 5	13 414	12 364	9 200
Replant at ratoon: 6	13 601	12 366*	8 690
Replant at ratoon: 7	13 727	12 304	8 142
Replant at ratoon: 8	13 793	12 194	7 603
Replant at ratoon: 9	13 844	-	-
Replant at ratoon: 10	13 878	-	-
Replant at ratoon: 11	13 889	-	-
Replant at ratoon: 12	13 891*	-	-

*Peak or optimum stage for replanting. Note for soil group 1 that the NPV curve is flat, suggesting that more than 12 ratoons might well be the economic optimum

Fallowing and green manuring

The practice of short summer fallowing for autumn planting, with or without cover cropping, has consistently resulted in very high yields in plant cane crops at Mhlume.

A comparison of 13 blocks of cane which were fallowed (and sometimes green manured using sunn hemp, *Crotalaria juncea*) with 13 similar land class blocks which received the standard cane-to-cane spring replant treatment is made in Table 4.

DISCUSSION

Hoekstra (1976), in a similar investigation, found that yield decline patterns for Huletts-Darnall fields all followed a similar slope, the differences between categories of replant frequency coming from different plant cane yields. In contrast, the Mhlume data show that plant cane yields are approximately the same, irrespective of planting frequency (or soil type), but that different categories of replant frequency show widely differing yield decline slopes. Perhaps the fully irrigated annual cropping regime at Mhlume

TABLE 4. Yield performances of fallowed and non-fallowed cane blocks at Mhlume

Treatment	Yield TCH						Total tons cane, 6 seasons
	Plant crop	1R	2R	3R	4R	5R	
Fallowed (A)	150	119	109	90	95	*	563
Non-fallowed (B)	103	95	88	86	79	76	527
Diff. (A - B)	**47**	**24**	**21**	**4**	**16**	**(76)**	**36**

*Note: This comparison accounts for the year in which the fallowed fields did not produce cane for harvest. Also, since many blocks contribute these data, there is a mix of seasons by ratoon stage, which improves the "average" yields obtained. It is not suggested that fallowed fields do not produce fifth ratoons. In practice there is evidence to suggest that fallowing may enhance the yields of older ratoons. However, in order to account fairly for the loss of production during the fallow year, the data were limited to six seasons has something to do with this difference. At Darnall the 19 to 20-month age of the crop means that the time of season at harvest varies quite widely over the life of a field. For example, a field cut in May one year is ready for harvest only in December of the next year. At Mhlume fields cut early in the season tend to remain in that season owing to the 12-month age of the cropping cycle. However, there is some deliberate shifting of month of harvest at Mhlume in order to accommodate the replant schedule. Thus fields coming up for spring replant in the forseeable future are shifted gradually to earlier harvest months so as to allow time for land preparation (May to July). Fields selected for fallowing and green manuring (autumn planting) are similarly shifted towards harvest at the end of the season (November).

In comparison of yields of fallowed with non-fallowed replants, it must be remembered that a *seasonal* factor is introduced. Fields that have been fallowed and green manured are planted in autumn, whereas non-fallowed replants are spring planted and harvested later in the season. Autumn planted and early cut fields in Swaziland enter the following spring and summer with a greater canopy and hence utilise solar radiation more effectively than spring replants and late season cut fields. From local crop canopy development studies made by the author it has been calculated that autumn plants experience seven months of high temperature and high incoming solar radiation with a 100 % canopy. By contrast, spring replants have an average canopy of only 79 % during the most favourable growing conditions.

This probably accounts for the yield differences reported by Sweet & Patel (1985) for which they proposed correction factors to be used when assessing cane yields at different harvest dates in Zimbabwe and Swaziland. Sweet & Patel (1985) "COTCHM" factors (corrected tons of cane per hectare per month) exceed 20 % for the October to December months.

It can be seen in Table 4 that the total tonnage of cane per hectare from autumn planted cane is only 7 % greater over the entire crop cycle (six years) than the tonnage from spring replants. If yields are compared from plant, first ratoon and second ratoon crops only, when the seasonal factor is most pronounced and when the fallow year effect is omitted, then the respective crop tonnages are:

Fallowed, autumn planted cane	-	378 t/ha
Spring planted cane	-	286 t/ha
Difference		**92 t/ha (32 %)**

The magnitude of this difference suggests that factors other than seasonal effects are involved in the yield improvements obtained. Intensive research is under way at Mhlume in the hope of identifying these factors (Nixon, 1988).

The economic analyses have produced interesting results. It can be seen from Table 3 that the optimum financial returns for different land class groups come from widely differing replant policies. The poor soils at Mhlume, which comprise at least 50 % of the area under cane, need to be replanted every four years (25 % annual programme). Fields in soil group 2 should have life extended to six ratoons (resulting in a 14 % annual replant programme for these soils). Group 2 soils cover 23 % of Mhlume's area under cane.

Fields on Group 1 soils appear on average to have an economic life of at least 13 years. This area occupies about 27 % of the total land and the annual replant programme required is 7,5 % or less. Specific years require specific replant decisions. However, *on average*, Mhlume will reap optimum financial benefits if the replant programme is about 17 % annually.

Efforts to improve yields overall and flatten the sharply declining ratoon yields on group 3 soils are at present focused on the fallowing and green manuring approach. How successful is this policy? In Fig. 4 the yield decline pattern of fallowed fields is compared with non-fallowed replants.

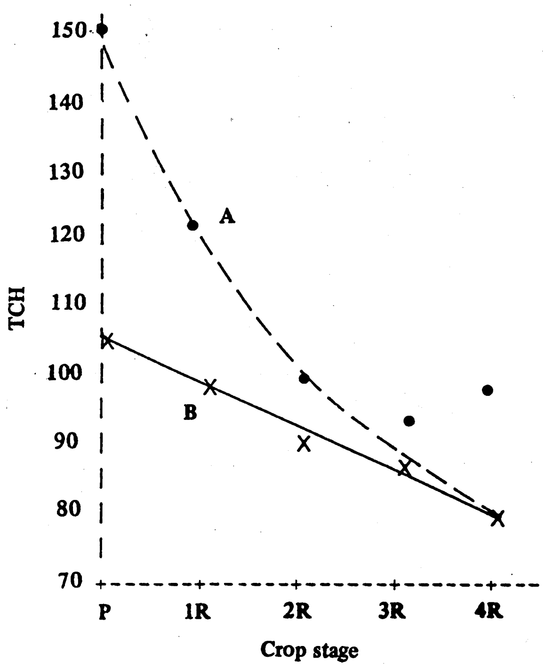

FIG. 4. Yield decline comparison between fallowed and non-fallowed fields

As would be expected, the practice of fallowing and cover-cropping has greatly enhanced yields in the early stages of the crop cycle. Eventually, however, yield declines follow a similar slope to those obtained from non-fallowed fields. An economic analysis was conducted on a derived yield model in which third and fourth ratoon yields were identical to those obtained in the non-fallowed fields. Using the same coefficients and technique as that employed in the optimum replant study above (Table 3), with the exception that additional land preparation and planting costs were included in the fallowing treatments, comparative NPV (15 %) values on these derived yield models were calculated.

In these financial analyses year 0 (starting point) is the crop before replanting, so that the decision "to fallow or not to fallow?" can be fairly compared.

Treatment		NPV 15%
A: Fallowed, green manured:	Plant + 4 ratoons	= R11 370
B: Non-fallowed:	Plant + 4 ratoons	= R10 627

Comparing NPVs on different cycle lengths on the above two models also showed that the optimum replant cycle under both fallowing and non-fallowing should be four years (plant + 3 ratoons). It is interesting to note that on optimum cycles the practice of fallowing before replanting results in an NPV (15%) of R12 426 per hectare over 30 years, some R1 373 or 12,4% greater than the optimum cycle for non-fallowed treatment. Sensitivity analysis of varying cane prices and discounting factors does not alter the conclusions. Clearly, with these responses being obtained at Mhlume, green manuring is a financially viable practice.

However, optimum returns from fallowing come from a short replant cycle because of the greatly enhanced plant and first and second ratoon yields. Fallowing may therefore not result in reduced replant programmes as was hoped, unless the yields from older ratoons are, in fact, improved. Further research is required to clarify this point.

Several other researchers have published data and reports on this stubble replacement decision. Krenz & Shapouri (1982) considered straight crop income and cash outflows without discounting. Alvarez and co-workers have considered a wide range of methodologies investigating this question. Crane *et al.* (1982) have published comprehensive deliberations on the subject. These workers incorporated the important concept of the time value of money, but also extended their considerations to include many other variables, including transport costs, seasonal growth factors, modes of harvest, etc.

In this paper a simplified approach has been adopted since the coefficients quantifying more precise field-by-field data are not known. However, the identification of distinct yield decline patterns by soil groupings and the use of NPV analyses has led to the fairly clear conclusions regarding optimum ratoon life at Mhlume.

SUMMARY AND CONCLUSIONS

- The average yield decline by ratoon stage at Mhlume over the period 1980 to 1987 is 4,8 tons per hectare per ratoon.
- This average pattern is made up of three distinctly different patterns from cane growing on three different soil (land class) groupings.
- The specific yield decline slopes for these three soil groups are:
  Group 1: about 1 TCH per ratoon
  Group 2: about 3,5 TCH per ratoon
  Group 3: about 10 TCH per ratoon
- Using NPV (15%) analyses, optimum financial returns are obtained on replanting these soil groups as follows:
  Group 1: after 13 or more years (plant + 12 ratoons)
  Group 2: after 7 years (plant + 6 ratoons)
  Group 3: after 4 years (plant + 3 ratoons)
- At Mhlume, because of the preponderance of poor soils, the optimum overall replant programme is about 17% per annum.
- On Mhlume's poorer soils the practice of fallowing and autumn planting results in greatly enhanced plant cane and first ratoon yields. This improvement is more than would be expected from the seasonal effect alone, pointing to other factors that play a part. These are being researched at the present time.
- Fallowing and green manuring, when it produces yield improvements as obtained at Mhlume, is a financially beneficial practice.

BIBLIOGRAPHY

CRANE, DONALD R., SPRIEN, THOMAS H., ALVAREZ, JOSE, & KIDDER, GERALD. (1982). An Analysis of the Stubble Replacement Decision for Florida Sugarcane Growers. *Bulletin 822 Agric. Expt. Stns* Univ. Florida

HILL, J.N.S. (1984). *The economic viability of three irrigation schemes in Ciskei* Report to the Ciskei Agricultural Corporation, Bisho, Ciskei

HILL, J.N.S., VAN VUUREN, E. & ELLIS, B. (1988). *The Mhlume Daily Diaries: a computerised farm management information system* (In press)

HOEKSTRA, R.G. (1976). Analysis of when to plough out a sugarcane field. *Proc. S.A. Sug. Technol. Ass.* 50: 103

IRVIN, GEORGE. (1984). *Modern Cost-Benefit Methods* Pub. by Macmillan Press, London

KRENZ, RONALD D. & SHAPOURI, HOSEIN. (1982). Optimum Sugarcane Planting Patterns in Texas. *The Sugar Journal.* Dec. 1982

NIXON, D.J. (1988). Mhlume (Swaziland) Sugar Company, Personal communication

NIXON, D.J., WORKMAN, M. & GLENDINNING, P.J. (1986). Soil and land Classification in Swaziland. *Proc. S.A. Sug. Technol. Ass.* 60: 216

SWEET, C.P.M., & PATEL, R. (1985). Changes in cane yield of irrigated variety NCo 376 due to season and their implications when evaluating field performance. *Proc. S.A. Sug. Technol. Ass.* 59: 210

WORKMAN, M., SCOTT, P.M. & NIXON, D.J. (1986). A review of the management and amelioration of saline/sodic soils at Mhlume (Swaziland) Sugar Company *Proc. S.A. Sug. Technol. Ass.* 60, 162