THE USE OF MICROCOMPUTERS AND SPREADSHEET PROGRAMMES TO AID REPLANT DECISION MAKING

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Abstract

The high cost of replanting sugarcane dictates that replant decisions be based on an economic analysis to determine the optimum replant year taking into account the time value of money. A spreadsheet programme, using Lotus 1-2-3, was developed at Inyoni Yami Swaziland Irrigation Scheme to conduct such an analysis. This uses yield models, based on historical performance in various soil classes, and estimated income and costs to produce discounted cash flow calculations over whole crop cycles. Replanting decisions are tested in the current and each subsequent year of the cycle. The year with the highest income indicates the optimum replant time. The programme can be used in any situation where yield, income and costs can be predicted.

Introduction

Inyoni Yami Swaziland Irrigation Scheme (IYSIS) is a sugar, citrus and livestock project situated in the N.E. Swaziland lowveld. The irrigated sugarcane area is divided into two estates. The western estate, Ricelands (formerly under paddy and upland rice) is 2 450 ha in extent and consists principally of sandstone-derived soils eg Sterkspruit, Kroonstad and Katspruit forms, but includes also a proportion of basalt-derived Tambankulu form. These soils are difficult to irrigate and typically support only 5 to 6 ratoons. Vuvulane estate to the east, 1 815 ha, lies in the shadow of the Lubombo escarpment on predominantly basalt-derived soils eg Hutton, Shortlands and Tambankulu forms. Crop cycles can be extended to 15 and, sometimes, more than 20 ratoons.

The decision to replant a cane field is based on one or more of the following:

- declining yield
- declining stool population
- poor drainage — surface and sub-surface
- increasing salinity and sodicity
- poor irrigation layout
- high pest infestation — particularly white grub
- high smut infestation, greater than 5% infected stools
- variety change

Yield decline is due to a combination of some of these factors and, particularly on the poorer soils, deterioration of sub-surface structure is due to irrigation. Compaction and sodicity are ameliorated at ploughout by gypsum applications and ripping to a depth of 400–600 mm. Whilst factors such as poor furrow layout and white grub infestation clearly indicate the need to replant, decisions based on yield decline are less certain. They involve the assumption that the increased economic return of higher yields will outweigh the high cost of replanting. To make the decision more objective, a tediously long calculation is required of the expected returns over the whole crop cycle. Estimated yields and costs per hectare of planting, growing and harvesting the crop are required in a discounted cash flow analysis. This takes into account the time-value of future money receipts and provides a comparison between the returns to be expected from replanting in the current year and postponing replant to a future year. A number of computer programmes have been reported to simplify and ease the calculations. Hoekstra[3] describes a complex system for use on a mainframe computer; and microcomputer programmes written on a spreadsheet and in Basic have been reported by Alvarez and Levins[1] and Chapman.[2] This paper describes a simple system which was developed at IYSIS on the Lotus 1-2-3 Spreadsheet to provide rapid analysis for immediate replant decision making and longer term estimates.

Yield Prediction

Reliable yield predictions are necessary for economic decision making. IYSIS has yield records for all fields over ten years. From these data, reasonably accurate historical profiles of the yields over whole crop cycles could be developed. It has been demonstrated by Sweet and Patel[5] that cane growth rate may vary markedly as a result of variables such as month of harvest and age of cane at harvest. In order to produce correction factors for these and for soil type, irrigation method and ratoon, the records were analysed at Rothamsted Experiment Station, England, using Genstat on a main-frame computer. The correction factors were applied to the annual yield of each block to provide 11,5 month old May harvest equivalents (corrected tons cane per hectare per month — COTCHM).

Analysis of the data showed that 4 characteristic profiles existed, relating COTCHM yield and ratoon. These represented the mean corrected yield for four broad groups of soils (Figures 1–4). The soil sets represented in each class were (Nixon[4]):

Class 1 — R, L sets (Hutton or Shortlands)
Class 2 — T, D, C sets — Vuvulane (Tambankulu, Westleigh, Bonheim)
Class 3 — T, D structured Z sets — Ricelands (Tambankulu, Westleigh, Sterkspruit or Estcourt)
Class 4 — Z, H sets (Sterkspruit, Kroonstad, Katspruit)

Class 1 soils corrected yields peaked in the first ratoon, declining gradually to the fifth ratoon and thereafter remained stable.

Class 2 soils yields also peaked in the first ratoon declining until the fourth ratoon, remaining stable until the eight ratoon and thereafter declining. Data were sparse for the ninth to thirteenth ratoons. Class 3 soils had a marked first ratoon peak, declining rapidly to the fourth ratoon and less markedly thereafter. Class 4 soils showed a steep linear decline from plant to fourth ratoon, stabilising at a low level for the remaining ratoons.

The normal IYSIS replant policy is to plough out fields in the early winter and plant in spring. Summer fallows and autumn planting are avoided where possible to prevent loss of production over the summer. All plant cane is cut in the final weeks of each harvesting season in order to achieve a target plant cane age of approximately 14 months. At Ricelands, where the average cycle is a plant crop and six ratoons,

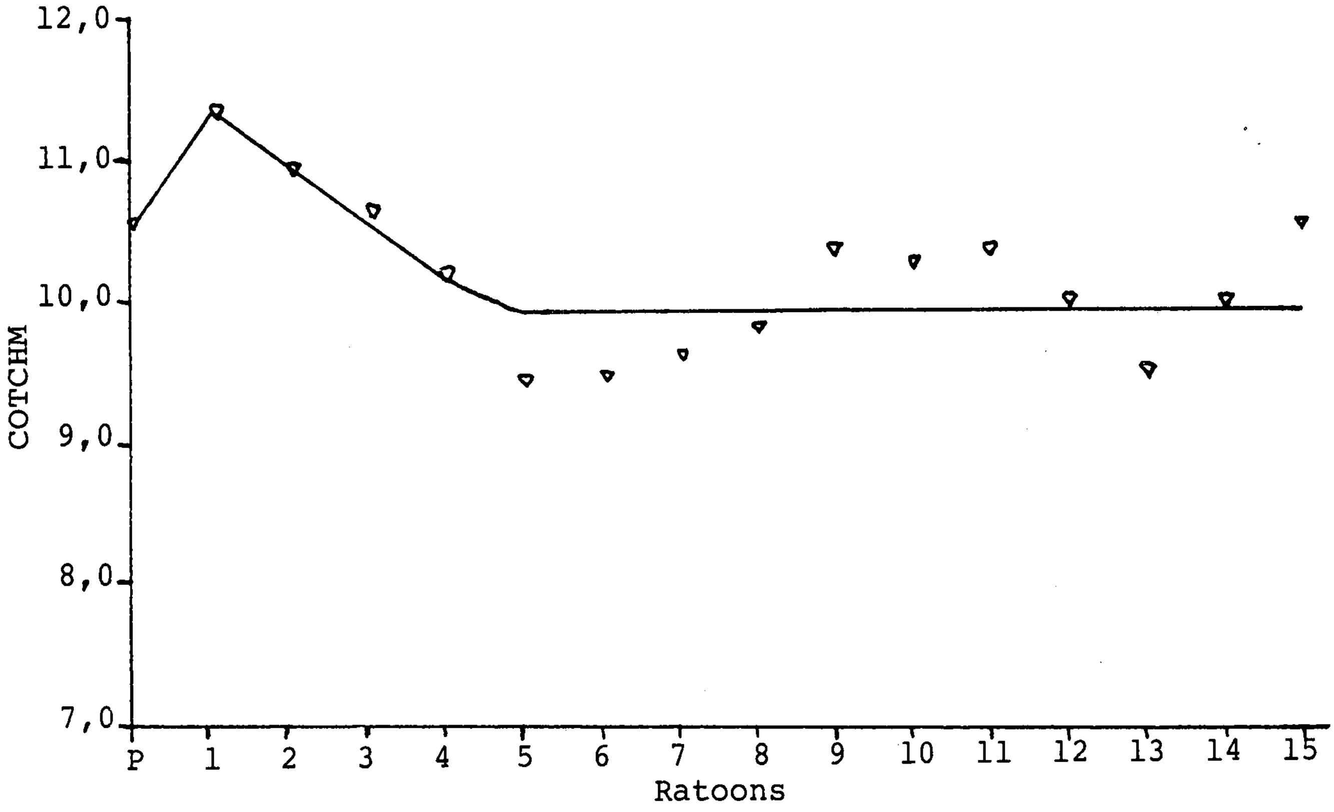

FIGURE 1 Corrected tonnes cane per ha per month (COTCHM) for ratoon cycle (Class 1).

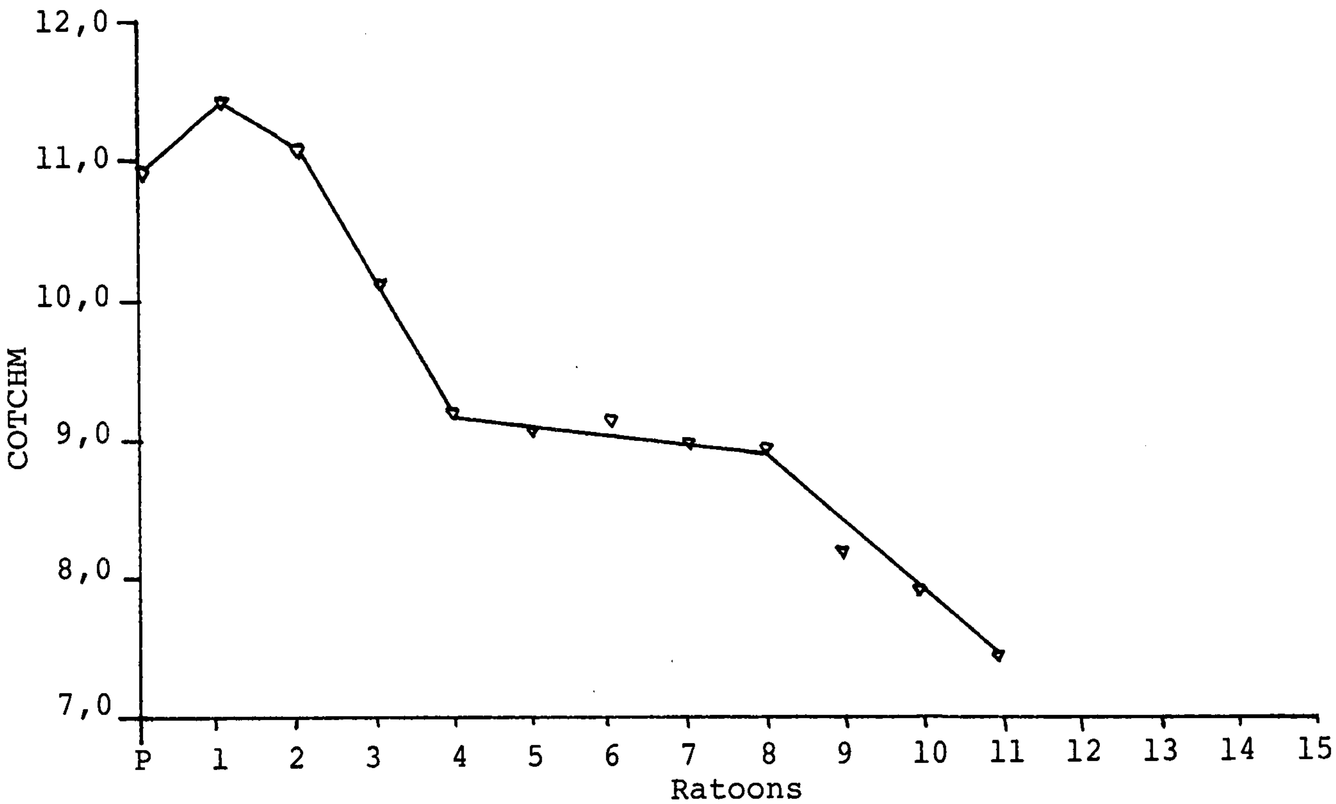

FIGURE 2 Corrected tonnes cane per ha per month (COTCHM) for ratoon cycle (Class 2).

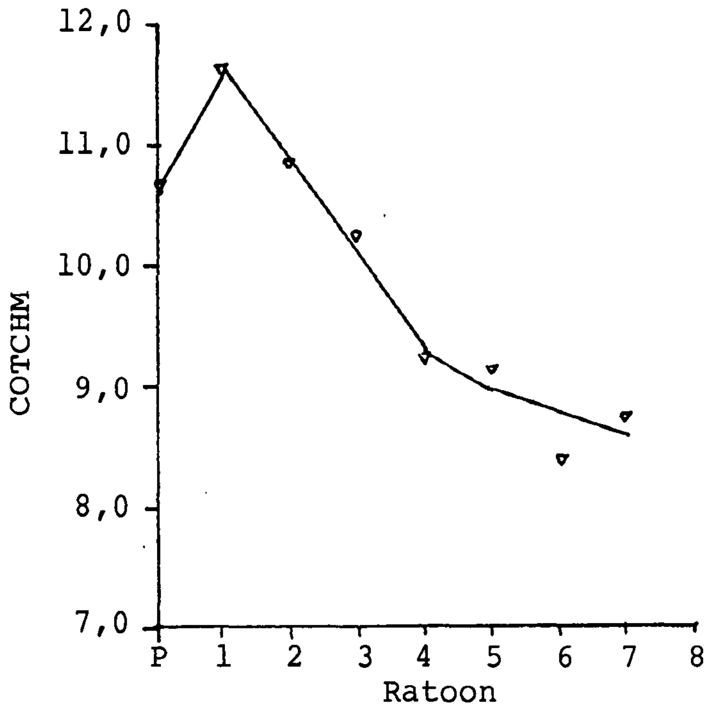

FIGURE 3 Corrected tonnes cane per ha per month (COTCHM) for ratoon cycle (Class 3).

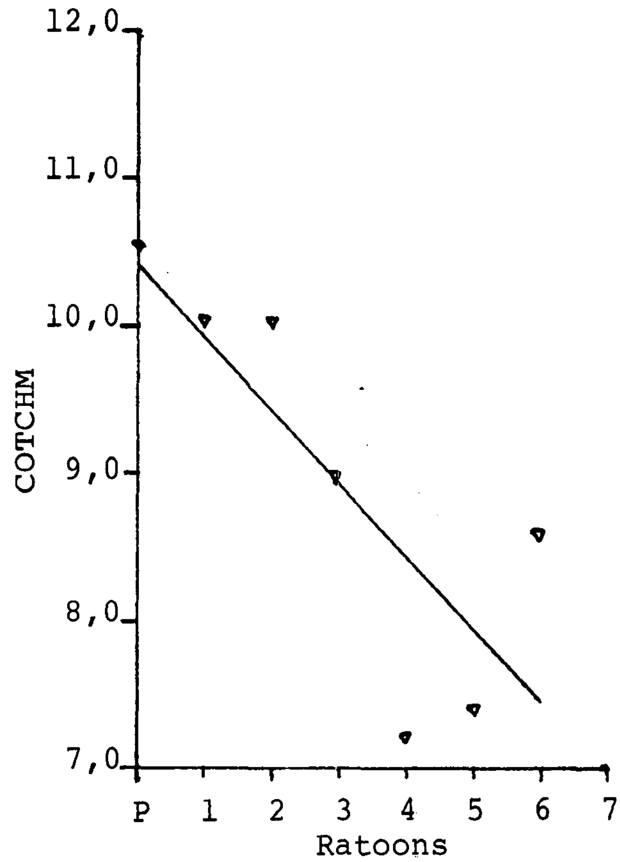

FIGURE 4 Corrected tonnes cane per ha per month (COTCHM) for ratoon cycle (Class 4).

the result is that each field moves back in the cutting programme towards the beginning of the 7 month harvesting season by one month per ratoon. The final ratoon will thus be cut in May, which is the ideal time. At Vuvulane, with its preponderance of better soils, crop cycles are extended beyond the tenth ratoon, and fields move back more gradually in the cutting programme.

In order to be able to use the profiles in financial calculations, yield predictions must be expressed in tons cane per hectare (referred to as TCH). Matrices of correction factors were developed in the original statistical analysis of the data and these were modified for each class that was discerned (Table 1). The matrices and a linear regression equation relating tons cane per ha per month (referred to here as TCHM) to age were used to correct the COTCHM yield profiles to actual cane yield in tons per hectare for each ratoon assuming that ratoons were harvested at a nominal 11,5 months (Class 1 and 2) or 11 months (Class 3 or 4) in a specific month of the season.

Table 1

Matrices showing the correction factors (CF) used for each yield class to convert tons cane per ha per month to COTCHM for cane harvested in a specified month and of specified ratoon to obtain May equivalent yields (TCHM x $\frac{100}{CF}$)

Ratoon	CLASS 1 — Harvest Months								Ratoon	CLASS 2 — Harvest Months							
	May	June	July	Aug	Sept	Oct	Nov	Dec		May	June	July	Aug	Sept	Oct	Nov	Dec
P	100	100	100	100	100	85	80	75	P	91	91	91	91	78	75	68	68
1	100	100	100	100	100	85	80	73	1	100	100	100	100	96	88	75	75
2	100	100	100	100	95	85	80	73	2	98	98	98	98	82	82	78	78
3	95	95	95	95	95	85	80	73	3	90	90	90	90	75	75	75	75
4	95	95	95	95	95	85	80	73	4	90	90	90	90	75	75	75	75
5	95	95	95	95	95	80	80	73	5	86	86	86	82	68	68	68	68
6	95	95	95	95	95	80	80	73	6	86	86	86	82	68	68	68	68
7+	90	90	90	90	85	80	80	73	7+	75	75	75	75	68	68	68	63

Ratoon	CLASS 3 — Harvest Months								Ratoon	CLASS 4 — Harvest Months							
	May	June	July	Aug	Sept	Oct	Nov	Dec		May	June	July	Aug	Sept	Oct	Nov	Dec
P	97	95	95	95	95	95	76	76	P	100	97	97	95	77	75	67	67
1	100	100	100	100	100	97	92	87	1	100	100	100	100	95	85	75	70
2	88	88	88	85	85	85	83	80	2	90	90	90	90	75	70	68	68
3	85	85	85	85	80	78	78	78	3	87	87	87	83	67	67	67	65
4	85	85	85	85	80	78	78	78	4	87	87	87	75	67	67	65	63
5	85	85	85	85	80	78	78	78	5	80	80	80	73	63	60	60	60
6	85	85	85	85	80	78	78	78	6	80	80	80	73	63	60	60	60
7+	83	83	83	83	78	78	78	78	7+	80	80	80	73	63	60	60	60

IYSIS REPLANT DCF ANALYSIS (FILE:RDA1)

ALT M -> Macro menu F9 = Calculate F10 = Graph

DATA INPUT TABLE

EST(R=1,V=2,10R=3)	1
FIELD:	S2-4
LAST CROP RATOON:	3
LAST CROP'S TCH:	125
YIELD PROFILE:	3
FACTOR X LAST TCH:	1
SUCROSE %	12.94
SUCROSE PRICE E:	310
DISCOUNT RATE:	0.07
HARVEST E/T:	8.60
PROFILE PLANT TCH	122.0
ADJUSTED PLANT TCH	0

NET PRESENT VALUE

NET PRESENT VALUE	E	% CHANGE
REPLANT YEAR 0	9207	0.0
REPLANT YEAR 1	9756	6.0
REPLANT YEAR 2	10066	9.3
REPLANT YEAR 3	10176	10.5
REPLANT YEAR 4	10104	9.7
REPLANT YEAR 5	9897	7.5
REPLANT YEAR 6	9589	4.1

STATUS: Automatic Yield Modelling

Last crop's TCH is NOT adjusted.
Profile Plant TCH is NOT adjusted.

MANUAL YIELD PREDICTION

	Full Cycle	Next five Ratoons
PL	0	0
R1	0	0
R2	0	0
R3	0	0
R4	0	0
R5	0	0
R6	0	I

Insert full cycle yields (Pl and 6 ratns) and next five ratoon yields assuming ploughout six years from now. Then press ALT Q. To return to automatic modelling press ALT A or reload file. (When auto has been over-written STATUS indicates "Manual Yield Prediction").

INFLATION FACTORS

	COSTS	PRICE
YEAR 0	0	0
YEAR 1	0	0
YEAR 2	0	0
YEAR 3	0	0
YEAR 4	0	0
YEAR 5	0	0
YEAR 6	0	0

COST TABLE

	RIC	VUVU	10R
	1	2	3
REPLANT	1520	1520	1520
CULT PL	1900	1565	1565
CULT RAT	1410	1530	1530

AUTOMATIC YIELD MODELLING

YIELD PROFILE TABLE

Profile	Year 0	1	2	3	4	5	6	7	8	9	10	11	12	13
1	118.5	0.895	1.019	1.046	1.018	1.003	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	113.1	0.930	0.954	0.978	0.988	0.992	1.000	1.000	1.000	0.994	0.967	0.935	1.000	1.000
3	122.0	1.048	0.951	0.937	0.943	0.956	0.968	0.979	1.000	1.000	1.000	1.000	1.000	1.000
4	120.8	0.861	0.936	0.970	0.995	0.972	0.940	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Yield modelling

Selected profile	122.0	1.048	0.951	0.937	0.943	0.956	0.968	0.979	1.000	1.000	1.000	1.000	1.000	1.000
PL cycle TCH per yr	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3	97.3	97.3	97.3	97.3	97.3
RT/PL cyc TCH per yr	117.9	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3	97.3	97.3	97.3	97.3
	117.9	112.7	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3	97.3	97.3	97.3
	117.9	112.7	109.1	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3	97.3	97.3
	117.9	112.7	109.1	106.8	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3	97.3
	117.9	112.7	109.1	106.8	106.8	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3	97.3
	117.9	112.7	109.1	106.8	106.8	106.8	122.0	127.9	121.6	113.9	107.4	102.7	99.4	97.3

FIGURE 5 Computer printout of main worksheet area showing data input table, cost table, yield profile table and examples of yield modelling and net present values.

Although the real situation is less tidy, the approximations are the most objective that could reasonably be achieved for the yield profiles. The COTCHM concept cannot accurately predict plant cane yields and average actual plant cane yields were calculated for each class. These and the corrected ratoon yields were used to develop smoothed and modified cane yield profiles which are expressed as a starting plant cane yield and a series of factors by which the previous year's yield is multiplied (Figure 5).

The Computer Programme

As replant takes place on average every 6 to 7 years at Ricelands the programme was designed to compare the returns from seven scenarios in which replanting takes place in the current and in each subsequent year. Figures 5 and 6 show part of the worksheet layout which consists of a data input area, the yield model, seven cash flow calculations and a table of net present values (NPV) of each cash flow. When the file is loaded into the computer's memory the screen displays the data input and NPV tables and three lines which indicate the file's status.

Data Input

At the beginning of the season the budget costs per hectare for the forthcoming year are entered into the Cost Table. These are variable costs which include depreciation and some direct overheads. The values shown were chosen for the sake of illustration but are reasonably realistic. Replant costs comprise land preparation and planting. Cultivation costs include all other operations except harvest and haulage and they differ for plant and ratoon crops. Harvesting costs are shown as a charge-out rate per ton of cane. For accounting purposes Vuvulane Estate is divided into Vuvulane and 10R areas and the Cost Table therefore provides figures for three different "farms".

The Data Input Table includes other fixed information such as the discount rate for the NPV calculations and the expected sucrose price for the current year. In order to minimise the amount of error involved in the large number of input variables, no effort is made to account for inflation on costs or sucrose price. The cash flow calculations are therefore kept in constant terms. A table for the input of inflation factors is provided should their inclusion be considered necessary. After the fixed information and yield model have been entered, the data to be changed for each analysis are: the estate (designated by a number from 1 to 3), field number, yield profile, last ratoon number and corrected last yield.

To prevent cell formulae from being inadvertently overwritten, an auto-execute macro command switches on global protection when the file is loaded. The cursor is placed in the input Table on the first of the entry cells which is unprotected. As automatic recalculation slows the entry of data, the programme is set to manual recalculation. Once the input data have been entered a macro calculates the spreadsheet, prints the Input and NPV Tables and returns the cursor to the first entry cell.

Automatic yield modelling

The yield profiles for each land class are entered in the Yield Profiles Table. Using the @LOOKUP function the programme refers to the Input Table for the yield profile number, selects the relevant profile from the Profile Table and calculates the yields for each year of a complete cycle. The ratoon yields are thus dependent upon the starting plant cane yield which is also automatically displayed below the Input Table. This can be adjusted to raise or lower all yields in the cycle if the field is considered to have a higher or lower potential than the average for the land class.

Inevitably some fields are harvested in months other than those assumed for the ratoon in the yield profiles.

To ensure that the last year's TCH is compatible with the profiles it is corrected to the appropriate month (for its ratoon number) before it is entered in the Input Table. This correction is carried out in a separate yields analysis system. The programme then uses it as the starting point to predict the yields of ratoons prior to the replant year. The @LOOKUP function refers to the Input Table for the last crop's ratoon and corrected TCH and multiplies by the relevant profile factors. An adjustment facility is again provided in the Input Table.

Manual Yield Prediction

When there is reasonable confidence that the yields of a field will conform to one of the yield profiles, automatic modelling is acceptable. However, the yields of some fields will be atypical and, in some cases, it is desirable to construct a specific yield profile or compare the effect of different yield scenarios. A manual yield over-ride facility has therefore been provided in which all the yields can be specified. Macro commands accomplish the over-ride and return the system to automatic modelling.

Status

The status lines, which appear at bottom left of the opening screen, indicate the mode of yield prediction (automatic or manual) and warn if the last crop's yield or starting plant cane yield have been adjusted. When the file is in automatic mode the @IF function tests the contents of the cells and displays the appropriate message. The status lines are overwritten when the manual mode macro command is executed.

Cash flows

The yield model for each year of replant is transferred automatically to the cash flow tables. The programme refers to the Input Table for sucrose percent (IYSIS 5-year average) and sucrose price and calculates the income for each year. Replant and cultivation costs applicable to the "farm" are extracted from the Cost Table.

Harvest and haulage costs are calculated from the cane tonnage and specified harvest charge. An additional cost for loss of production during the fallow period is included in the replant year and is taken as being equivalent to 2,5 months production at the yield of the following plant crop. Finally, total costs are subtracted from the income to give net cash flows (NCF) for each year (see example in Figure 6).

CASH FLOW	REPLANT IN YEAR 2						
YEAR	0	1	2	3	4	5	6
TCH	84.9	81.1	122.0	127.9	121.6	113.9	107.4
INCOME	3404	3255	4894	5129	4878	4570	4310
COSTS							
REPLANT	0	0	1520	0	0	0	0
CULTV.	1410	1410	1900	1410	1410	1410	1410
HARVEST	730	698	1049	1100	1046	980	924
PROD LOSS	0	0	874	0	0	0	0
Total	2140	2108	5343	2510	2456	2390	2334
NCF	1265	1147	-449	2619	2422	2180	1976

FIGURE 6 Computer printout showing an example of a cash flow table.

Net present value table

The @NPV function is used to discount each net cash flow line to the present at the specified discount rate. Seven different net present values, corresponding to replant in each of the seven years, appear in the NPV Table. A percentage change calculation compares each figure against the figure for replant in the current year. The spreadsheet's graph facility can be invoked to provide a visual presentation of the results.

Making the replant decision

In the example shown in Figure 5 the last crop's TCH is 125 and the NPV for replanting in the current year is R9 207. It increases to R9 756 (6%) if delayed by a year and is highest for replant in year 3 (+10,5%). Thereafter the NPV falls with each succeeding year that replant is delayed. The programme therefore indicates that over the period the highest returns will be made if replant is postponed until year 3 which, in the example, is after the seventh ratoon. However, the returns for replant in years 2 and 4 are similar and probably well within the margin of error. In this case some discretion in the choice of year is thus possible.

```
IYSIS REPLANT DCF ANALYSIS              (FILE:RDA1)
##################################################################
ALT M -> Macro menu         F9 = Calculate            F10 = Graph
------------------------------------------------------------------
DATA INPUT TABLE                        NET PRESENT VALUE   E    % CHANGE
----------------------------            ---------------------------------
EST(R=1,V=2,10R=3)         1            REPLANT YEAR 0    13496      0.0
FIELD:                  S2-4            REPLANT YEAR 1    13345     -1.1
LAST CROP RATOON:          3            REPLANT YEAR 2    12988     -3.8
LAST CROP'S TCH:         125            REPLANT YEAR 3    12454     -7.7
YIELD PROFILE:             3            REPLANT YEAR 4    11754    -12.9
FACTOR X LAST TCH:         1            REPLANT YEAR 5    10927    -19.0
SUCROSE %              12.94            REPLANT YEAR 6    10013    -25.8
SUCROSE PRICE   E:       310            ---------------------------------
DISCOUNT RATE:          0.07
HARVEST E/T:            8.60            STATUS: Automatic Yield Modelling
                                        #################################
PROFILE PLANT TCH      122.0            Last crop's TCH is NOT adjusted.
ADJUSTED PLANT TCH       150 ##         # WARNING: Plant TCH is adjusted #
------------------------------------------------------------------

IYSIS REPLANT DCF ANALYSIS              (FILE:RDA1)
##################################################################
ALT M -> Macro menu         F9 = Calculate            F10 = Graph
------------------------------------------------------------------
DATA INPUT TABLE                        NET PRESENT VALUE   E    % CHANGE
----------------------------            ---------------------------------
EST(R=1,V=2,10R=3)         1            REPLANT YEAR 0     9207      0.0
FIELD:                  S2-4            REPLANT YEAR 1     8784     -4.6
LAST CROP RATOON:          3            REPLANT YEAR 2     8225    -10.7
LAST CROP'S TCH:          90            REPLANT YEAR 3     7549    -18.0
YIELD PROFILE:             3            REPLANT YEAR 4     6759    -26.6
FACTOR X LAST TCH:         1            REPLANT YEAR 5     5880    -36.1
SUCROSE %              12.94            REPLANT YEAR 6     4944    -46.3
SUCROSE PRICE   E:       310            ---------------------------------
DISCOUNT RATE:          0.07
HARVEST E/T:            8.60            STATUS: Automatic Yield Modelling
                                        ---------------------------------
PROFILE PLANT TCH      122.0            Last crop's TCH is NOT adjusted.
ADJUSTED PLANT TCH         0            Profile Plant TCH is NOT adjusted.
------------------------------------------------------------------
```

FIGURE 7 Computer printout showing examples in which net present values change due to changes in plant cane TCH (upper) or last crop TCH (lower).

In the first example shown in Figure 7 the same field has a last crop TCH of 125 but the plant cane yield has been adjusted up to 150 t/ha. The expected improvement on replant is higher and an earlier replant is indicated. The second example in Figure 7 shows the field with a much lower last crop yield of 90 t/ha. The NPVs fall precipitously from the current year and immediate replant is indicated.

The replant programme

Long term financial estimates for 5 year periods are updated each year. A 5-year replant programme is therefore required and all fields are routinely put through the analysis after harvest.

A roughly even annual programme is produced at season end using some discretion in assigning fields to replant years. Minimum equipment levels can then be determined and the need to maximise machinery use balanced against the savings to be made from extending crop cycles. Other capital requirements, engineering and labour needs, and the provision also of seedcane can then be adequately planned.

In order to make final decisions on the current and forthcoming year's replant programmes, the analyses of all fields indicated as requiring immediate replant are reassessed. The yield model produced by the programme is compared with the field's past and expected future performance. If a unique yield profile is applicable the manual yield over-ride facility is used. A variety of possible profiles may be tried to determine the minimum yield levels which will justify either postponement or advancement of the date of replant.

Discussion

The COTCHM concept provides an important tool for improving assessment of field performance. However there are some difficulties involved in moving from a corrected growth rate to a yield of sugar, on which to base an economic analysis. Assumptions have had to be made in connecting ratoons to a particular month of harvest and in smoothing and extending the profiles. Some calculations have been simplified and considerable error is possible in the other variables on which the calculations depend. This must be borne in mind and all factors carefully considered before a final decision to plough out a field is made.

The programme is particularly sensitive to predicted yield. At IYSIS the COTCHM process, involving detailed statistical analysis of a large database, was chosen to characterise the yield profiles. However a simpler method will be adequate if it provides yield predictions on which economic decision making can be confidently based.

The spreadsheet programme is easily adapted and will be a useful tool for any grower able to estimate yield, costs and income and wishing to reduce future operating costs.

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