USE OF A COMPUTER AS A MANAGEMENT AID TO CROP PREDICTION DURING TIME OF RESTRICTION

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Abstract

With the advent of quota restriction in 1978, it was decided to investigate the feasibility of using a computer to simulate the results of various courses of action available to management and to facilitate the selection of the most advantageous management policy to be followed. The objective was to be able to emerge from the restriction period in the strongest possible condition and ready to resume maximum production in the shortest possible period of time. The approach adopted was to follow the traditional method of crop prediction and to use the computer to do the forbiddingly large volume of calculations and clerical work involved in examining the various management policy options available and projecting the results of these policies three to five years ahead. It was appreciated that in the short term the section manager would be more accurate predicting crop yields than the computer, but that in the long term, it would be impractical to expect accurate three to five-year predictions. It was agreed that with the computer, not only was it feasible to calculate the results of the various management options, but also that the computer had the capability of projecting those results into the future and coming back to year one starting with alternative parameters if the outcome of the option tried was not in accordance with the long-term objectives of the company.

Introduction

In 1978 the South African sugar industry introduced restrictions on production to fulfil its obligations under the International Sugar Agreement. At that point it was difficult to predict how long the restrictions would last, or how severe they would be, but there appeared to be a good chance that they would be both long-lasting and severe.

The management of the estates of C.G. Smith Sugar Limited had to decide on a policy for the restriction period which would have the least deleterious effect on the estate's ability to return to maximum production in the shortest period of time after the lifting of restrictions. In other words management required to know (or at least have some idea of) the effect of :

fallowing land
reducing fertilizer applications
modifying replanting percentages
increasing the age of unharvested cane.

It was felt that the estimates of production for future years should be done on a field by field basis, and as experience has shown that this is a very tedious process at best, a manual calculation method was considered to be impractical. It was therefore decided to investigate the use of a computer to do these calculations.

The first step in utilizing the computer was to define the objective of the programme.

Objectives of the Computer Programme

Speed

In compiling an estimate there are a large number of calculations necessary and to examine different options escalates this number. Therefore it was necessary to be able to do the calculations quickly.

Simplicity

The programme package had to be such that the parameters by which the computer determined the individual field yields were easy to understand, formulate, modify and update by people not highly versed in computer technology.

Field by Field Process

Detailed field by field and section by section crop estimates were necessary to make them of practical use to section staff and enable them to adjust the estimate as an integral part of the programme.

Recalculations

The facility to recalculate crop estimates, using different criteria applied to the same basic data, was required.

Projections

It was desirable to be able to project a simulated crop production cycle up to five years ahead.

Outline of Programme Steps

To enable a computer programmer to compile a prediction programme it was necessary to define the steps which have to be followed to arrive at a crop estimate, a replant programme and future field dispositions.

The method followed was the accepted system of using historical data to predict future performance. The programme had to fulfil the following requirements :

1. Select fields to be harvested on a rational basis, using preselected criteria.
2. Allow modifications of this selection necessitated by other factors and then to finalise the harvest prediction.
3. List fields available for ploughout and replant.
4. Allow management to select ploughout and replant candidates.
5. Show the field disposition after the above decisions had been made.
6. Repeat the above processes to estimate future crops.

Parameters required for Crop Prediction

Basic Data

To enable the computer to carry out the required calculations, certain basic inputs were required. These were :

field number
field area
current crop cycle, and
age as at 1st April of the year concerned.

Variety and soil type were also listed, but were not required for the computer calculations, and were merely supplementary information for use when deciding on manual corrections to be made to the computer predictions.

Age of Cane

Age of cane was calculated from the month in which the field was cut or planted to the month in which it was harvested. Complete months only were used; the month of planting or harvesting was taken as that month in which the majority of the area was planted or harvested.

Growth Cycle

Crops cut at different times of the year and growing through different seasons of the year have different growth potentials. It was therefore necessary to investigate the effects of time of season on growth.

An analysis was done of yields by fields and age through the harvest season. To simplify the parameter the year was divided into four parts, which approximated the four seasons. The result of this analysis was a table split into four "seasons", each "season" having a list of factors for cane ages commencing from 10 months. Thus crops of equal age cut in different seasons would have different growth factors and consequently different yields. (See Figure).

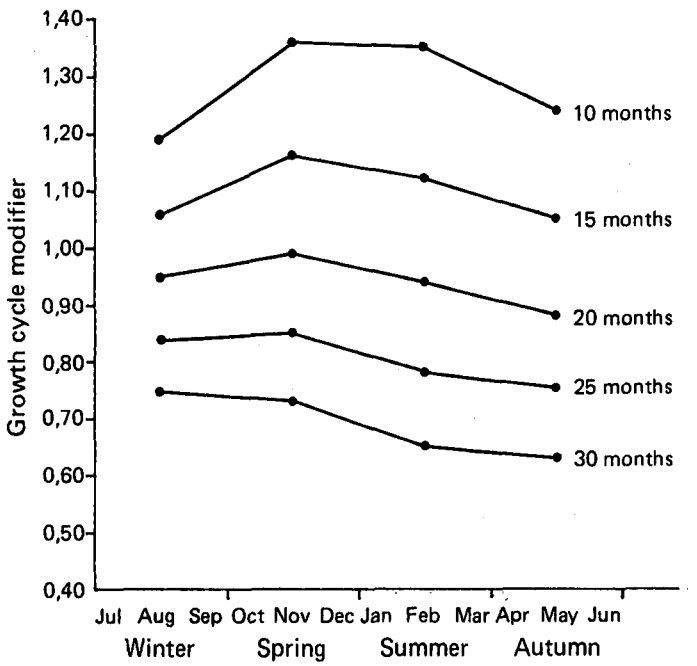

FIGURE Growth cycle modifier. Graphical illustration of growth cycle modifier, relating season to age of cane.

Climatic Effects

When making a crop estimate, it is often necessary to anticipate the expected type of growing season. A climatic correction modifier was introduced for this purpose to allow the yields over the entire estate to be either increased or decreased.

Section Yield Potential

It was anticipated that there could be differences in growth potential between sections due to factors such as soil type, altitude, annual rainfall or possible differences in management practices. To cater for this a section modifier was incorporated in the programme, which enabled increases or decreases to a section growth potential to be made in relation to other sections.

Cane Growth Potential

The key to the success of these prediction (simulation) programmes is the yield category classification, based on growth potential. Growth potential may be an alternative description of yield category. Growth potential per unit of time is a function of many factors among which are :

soil type
soil depth
aspect
rainfall and irrigation
physiological crop decline, with increasing ratoons.

However, as it is difficult to correlate growth with these parameters, historical yield data were used to quantify growth potential. Historical yields were listed by field from plant crop through the ratoons, using yield in tons cane per hectare per month as the common denominator. It became obvious that the effect of seasons was masking yield trends. It was possible to compensate for the effect of season by using the Kej concept described by Hoekstra[1] and a good correlation was achieved between actual and calculated section yields. (See Table). However, it was found that yield category data tended to vary from estate to estate, and therefore should be calculated for each estate individually.

Procedures Followed

Establishing the Yield Category Table

The yield category table was calculated by deciding on the range of plant cane yields (expressed as tons of cane per hectare per month) based on historical data. The decline in yield for the ratoon crops was estimated on the basis of historical data and allowance was made for those fields where the decline in the ratoons was likely to be more rapid than in other fields. From this information a yield category table was generated and each field was used by the computer programme to calculate a field by field crop estimate.

Concept of Estimating

The basis of the crop prediction was the traditional concept of crop estimation. In this traditional approach estimating age of the crop at harvest, area of field and yield potential were all taken into account and a tonnage per hectare per field was estimated.

TABLE
Kej Factor calculation

$$\text{(Kej Factor} = \frac{\text{10 Year mean tc/ha/m}}{\text{Season mean tc/ha/m}}\text{)}$$

Item	Estate	Season										
		70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80	10 Year mean
tc/ha/m	Addington ..	5,65	5,60	5,55	5,63	5,84	7,26	7,08	6,12	6,75	5,25	6,07
tc/ha/m	Gledhow ..	4,44	5,32	4,46	4,78	5,51	5,74	6,49	5,79	5,73	4,54	5,29
Kej Factor	Addington ..	1,07	1,08	1,09	1,08	1,04	0,84	0,86	0,99	0,90	1,16	—
Kej Factor ..	Gledhow ..	1,19	0,99	1,19	1,11	0,95	0,92	0,82	0,91	0,92	1,17	—

Programme Steps

Having met the prerequisite of providing basic data, the composition of the programme package was then resolved into the following steps :

1. A computer-generated *Preliminary Estimate* was produced by sorting all fields into sections and age in descending order. After the sort, the harvest yield was calculated using the sorted order of fields. These yields were calculated taking into consideration age at harvest, and the yield modifiers, viz. growth cycle, yield category, climatic correction, and section. The calculated monthly delivery rate was used to determine the month of harvest of the cane (see Appendix I — Harvest Selection).
2. Opportunity to alter manually the harvest selection criteria used. More detailed criteria were rejected as they would serve only to complicate the programme. After any alterations had been made the computer generated the final estimate (see Appendix II — Harvest Finalisation).
3. Th computer then printed a list of all fields that were fallow, out of production and which were second ratoon and older, from the fields in the final estimate produced above (see Appendix III — Ploughout/replant selection).
4. A manual selection of fields to be ploughed out and replanted could then be made.
5. A new crop disposition was then created from the simulated cane production operations above as at the 1st April of the next year. The programme aged all fields and adjusted the ratoon status of each field according to the simulated harvest and replanting programmes.

Discussion

The programme proved very useful in projecting the results of management decisions in times of restriction. It was possible to start from the current situation and proceed to examine management options, comparing the various effects on future field and crop dispositions. An additional advantage of the analysis of estate records to develop the basic data for the programme was a better understanding of the factors affecting cane growth. Generation of a preliminary estimate has been found to be of practical value to section staff faced with the task of compiling first estimates.

This programme package is by no means a passive object, but a dynamic ever-adjusting growing tool. Parameters such as yield category, section modifier and growth cycle modifier vary from season to season and need constant revision and refinement as additional data become available, thereby becoming more and more accurate. The first programme package was designed to apply to restriction conditions and there is now an obvious need for it to be adapted to apply to normal production years, where the final output is annual potential yield.

Conclusion

It was considered that the investigation was well worth while, because, in order to compile the necessary data a close look had to be taken at what was happening on the estates. In so doing a better insight has been gained into growth factors applicable to the various estates. Furthermore a very useful tool has been developed, which, with additional work, is expected to become even more useful and versatile. It has been noted that, while section by section simulated yields fairly closely approximate actual yields, individual field yields tend to fluctuate wildly about the mean.

Acknowledgement

The authors would like to acknowledge the assistance of Barry Burgess, who wrote the programme and who contributed to the thought processes involved.

REFERENCES

1. Hoekstra, R. G. (1976). Analysis of when to plough out a sugarcane field. *SASTA Proc* **50** : 103-113.

APPENDIX I

Harvest Selection Listing

Field	Area	Yield Cat	Cycle	Age	Month	Tons/ha	Total tons	Soil Type	Variety	Remarks
SECTION: ADDINGTON		TONS OF CANE REQUIRED: 31 079					MODIFIER 1,2			
1 171	12,1	32	R2	21	April	124,4	1 506,4	L. Ecca	NCo 376	JT 1 + 2
1 172	3,5	32	R3	21	April	124,4	435,7	L. Ecca	NCo 376	JT 1 + 2
1 200	15,2	20	R3	20	May	107,8	1 639,2	DL-L.ES-GS	NCo 376	
1192	14,6	48	R3	19	May	144,8	2 115,2	DOL-L. Ecca	NCo 376	
1191	4,9	48	R2	19	May	146,3	717,2	DOL-L. Ecca	NCo 376	
1342	3,0	34	R2	16	May	95,7	287,2	Red Sand	N 55/805	
1341	6,8	34	R1	17	June	105,9	720,4	Red Sand	N 55/805	
1322	15,1	53	R1	17	June	133,6	2 017,7	G & R SD-M.E.	N 55/805	
1211	15,7	37	P	15	June	112,8	1 772,4	DOL-L. Ecca	NCo 376	
1141	14,7	73	P	16	July	169,6	2 493,4	Alluvium	NCo 376	I cut yearly seed
1240	7,0	78	P	16	July	176,8	1 238,1	DOL-L. Ecca	NCo 376	
1321	10,4	63	P	16	Aug.	128,5	1 337,1	G & R SD-M.E.	N 55/805	
1272	1,6	40	R1	15	Aug.	110,3	176,6	DOL-L. Ecca	NCo 376	
1273	33,1	40	R3	15	Aug.	110,3	3 653,4	DOL-L. Ecca	NCo 376	
1112	2,5	60	R3	15	Aug.	128,0	320,2	AL-DW-DOL	NCo 376	JT 1 & 2
1131	13,0	36	R1	15	Sept.	105,8	1 375,9	DOL-L. Ecca	NCo 376	
1271	2,0	40	P	15	Sept.	110,3	220,7	Grey Sand	NCo 376	Very poor area
1151	13,5	78	R2	15	Sept.	132,1	1 784,6	DOL-L. Ecca	NCo 376	
1132	11,9	36	R2	15	Oct.	106,8	1 271,4	D-OLL. Ecca	NCo 376	
1152	6,2	78	R3	15	Oct.	118,8	736,6	DOL-L. Ecca	NCo 376	
1111	13,5	60	R2	15	Oct.	132,0	1 782,8	AL-DW-DL	NCo 376	JT 1 & 2
1280	3,0	97	R2	16	Nov.	195,5	586,6	Alluvium	NCo 376	Cut yearly
1160	20,2	49	R5	15	Nov.	92,2	1 862,9	DOL-L. Ecca	N 55/805	Plough out
	Sub Total						30 052,7			
	Remainder to Cut						1 026,2			
	Area cut as % of Section						49,2			
	Average Age of Sub Total						16,3			
	Average Tons/Hectare of S/T						123,4			
	Average Tons/Hectare Month of ST						7,5			

SELECT FROM THESE FIELDS FOR THE REMAINDER TO CUT

Field	Area	Yield Cat	Cycle	Age	Month	Tons/ha	Total tons	Soil Type	Variety	Remarks
1220	20,3	57	R4	16	Dec.	110,3	2 240,7	DL-L. EC-AL	NCo 376	Add 3 ha to 1141
1250	24,3	53	P	16	Dec.	132,3	3 217,0	DOL-L. Ecca	N 55/805	
1291	2,0	81	R2	16	Dec.	165,2	330,5	M.EC-DL-GS	NCo 376	Plough out
1292	16,2	81	R5	15	Dec.	140,9	2 283,2	M.EC-DL-GS	NCo 376	Plough out
1102	3,0	80	R4	15	Dec.	169,8	509,4	Alluvium	NCo 310	I cut yearly
1101	36,2	80	R4	15	Dec.	169,8	6 147,1	Alluvium	NCo 376	I cut yearly
1260	16,5	75	R2	14	Dec.	125,3	2 067,9	DL-L&M Ecca	NCo 376	
1302	14,0	75	R2	14	Dec.	125,3	1 754,6	DOL-M Ecca	NCo 376	
1301	10,1	75	R1	14	Dec.	145,1	1 465,7	DOL-M Ecca	NCo 376	
1310	18,1	75	R3	13	Dec.	101,2	1 832,9	DOL-R&G.SD	N 55/805	
1212	15,0	37	R1	13	Dec.	106,1	1 592,3	DOL-L. Ecca	NCo 376	

APPENDIX II

HARVEST FINALISATION

SECTION: ADDINGTON TONS OF CANE REQUIRED: 31 079 MODIFIER 1,2

Field	Area	Cycle	Age	Age cut	Tons/ha	Tons/ha/m	Tons	Monthly ha	Totals Tons	Month	Progress Total
1171	12,1	R2	21	21	124,4	5,9	1 506,4				
1172	3,5	R3	21	21	124,4	5,9	435,7	15,6	1 942,1	April	1 942,1
1322	15,1	R1	15	16	130,6	8,1	1 972,1				
1191	4,9	R2	18	19	146,3	7,7	717,2				
1192	14,6	R3	18	19	144,8	7,6	2 115,2	34,6	4 804,5	May	6 746,7
1200	15,2	R3	19	21	109,6	5,2	1 666,8				
1341	6,8	R1	15	17	105,9	6,2	720,4				
1342	3,0	R2	15	17	97,9	5,7	293,9				
1280	3,0	R2	9	11	149,9	13,6	449,8				
1240	7,0	P	13	15	171,9	11,4	1 203,7	35,0	4 334,8	June	11 081,6
1220	20,3	R4	8	11	84,6	7,6	1 718,2				
1212	15,0	R1	5	8	53,7	6,7	806,0				
1131	13,0	R1	10	13	97,8	7,5	1 271,9				
1132	11,9	R2	9	12	91,1	7,5	1 084,3	60,2	4 880,6	July	15 962,3
1211	15,7	P	13	17	118,8	6,9	1 865,3				
1141	14,7	P	13	17	173,5	10,2	2 551,1	30,4	4 416,4	August	20 378,7
1321	10,4	P	12	17	132,5	7,7	1 378,4				
1272	1,6	R1	11	16	113,2	7,0	181,1				
1273	33,1	R3	11	16	113,2	7,0	3 748,5	45,1	5 308,2	September	25 686,9
1112	2,5	R3	11	17	135,4	7,9	338,7				
1271	2,0	P	10	16	113,2	7,0	226,4				
1151	13,5	R2	10	16	135,6	8,4	1 831,1	18,0	2 396,3	October	28 083,3
1152	6,2	R3	9	16	124,3	7,7	770,9				
1111	13,5	R2	9	16	138,2	8,6	1 865,8				
1160	20,2	R5	8	15	92,2	6,1	1 862,9	39,9	4 499,6	November	
Section Totals		—	—	—	—	—	—	278,8	32 583,0		
Section Average		—	—	15,6	116,8	7,4					

APPENDIX III

REPLANT/PLOUGHOUT SELECTION LISTING

Field	Area	Yield Cat	Cycle	Month	Soil Type	Variety	Remarks
Section: Addington		—	—	Replant Area	74,115		Replant % 15
				Ploughout Area	14,823		Ploughout % 3

FALLOW

Field	Area	Yield Cat	Cycle	Month	Soil Type	Variety	Remarks
1292	18,2	82	F	—	M.EC-DL-GS	NCo 376	
1220	16,3	76	F	—	DL-L.EC-AL	NCo 376	3 ha given to 1141
1101	39,2	82	F	—	Alluvium	NCo 376	I cut yearly 3 ha 310
	Area				73,7 ha		
	% of Total Area				14,9%		

CANDIDATES FOR PLOUGHOUT

Field	Area	Yield Cat	Cycle	Month	Soil Type	Variety	Remarks
1230	18,4	57	R6	December	L.Ec-GSand	N 55/805	
1221	4,0	76	R5	June	DL-L.Ec-AL	NCo 376	
1280	3,0	97	R5	November	Alluvium	NCo 376	Cut yearly
1180	10,1	37	R4	April	DOL-L.Ecca	NCo 376	
1192	19,5	51	R4	May	DOL-L.Ecca	NCo 376	4,9 ha R-1
1273	36,7	57	R4	August	DOL-L.Ecca	NCo 376	2 ha GS R-3; 1,6 ha R-2
1310	18,1	76	R4	December	DOL-R&G.SD	N 55/805	
1332	9,0	31	R3	April	G & R Sand	N 55/805	
1111	16,0	73	R3	July	AL-DW-DL	NCo 376	2,5 ha R-1
1302	24,1	57	R3	July	DOL-M Ecca	NCo 376	10,1 ha R-1
1151	19,7	82	R3	October	DOL-L Ecca	NCo 376	6,2 ha R + 1
1260	16,5	73	R3	November	DL-L&M ECC	NCo 376	
1331	9,3	31	R2	April	G & R Sand	N 55/805	Poor Soil
1341	9,8	48	R2	May	Red Sand	N 55/805	3 ha R + 1
1131	24,9	57	R2	June	DOL-L Ecca	NCo 376	11,9 ha R + 1
1322	15,1	57	R2	September	G&R.SD-M.E.	N 55/805	
1212	15,0	51	R2	November	DOL-L. Ecca	NCo 376	JT 1 + 2
1141	14,7	63	R2	December	Alluvium	NCo 376	1 cut yearly
	Area				283,9 ha		
	% of Total Area				57,4%		