A METHOD FOR CHOOSING THE MOST PROFITABLE COMMERCIAL SUGARCANE VARIETY

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Abstract

The large number of new varieties now available to growers provides an important management option which should be exercised in the most informed manner. A computer programme was developed to assist the grower or advisor in choosing the most profitable variety for a given field or group of fields. The varietal characteristics considered were (1) sucrose yield; (2) sucrose content in relation to harvest and transport cost; (3) canopy development in relation to weeding cost; (4) ratooning ability in relation to re-establishment cost; (5) drought resistance in relation to drought frequency; (6) lodging in relation to harvest costs; (7) disease susceptibility in relation to roguing and replanting costs; (8) eldana susceptibility in relation to the annual mean planting and ratooning cost.

Introduction

The relatively large number of new varieties now available to growers provides them with an opportunity which should be taken in the most informed manner. The release of a new sugarcane variety depends largely on its sucrose yield and its resistance to pests and diseases, but other agronomic characteristics may also influence the economics and management of the variety. Many characteristics, including yield and resistance to pests and diseases, were measured in agronomic variety trials conducted by the Experiment Station over the past 20 years. These data have been used to develop a computer programme which can assist growers in making the best economic choice of variety for a given field or group of fields. The programme may be viewed either as a means of processing a grower's own observations regarding his environment and varieties, or as a current summary of the Experiment Station's continuing research and advice on released varieties.

Method

A data base was compiled from the results of over 350 harvests of released variety trials (RVT). Each trial consisted of four to 10 varieties, always including NCo376, and four to nine replications. Soil and leaf samples were taken at appropriate times and fertilizer was applied to ensure that all varieties were adequately supplied with nutrients. Irrigation was applied only in the northern region where it is a normal practice. The characteristics of new varieties were commonly compared with those of NCo376 which is still the standard variety in most regions of the South African sugar industry.

How the programme operates may be seen in Table 1 which illustrates the features of the programme, whilst not necessarily representing a real situation. Items 1 to 15 establish the conditions of the environment for which a variety assessment is required. The following items need some explanation:

Item (4). The environmental yield potential is the mean annual yield of NCo376 which is limited only by the climate and soil physical properties. This value may be given by the grower or may be obtained from a crop growth model which is being developed at the Experiment Station (Inman-Bamber & Thompson[2], Inman-Bamber [unpublished data]).

Item (5). A severe drought is defined as one that would kill most stalks of NCo376. The frequency of this event was determined with the help of the sugarcane growth model.

Item(6). It was assumed that the environmental yield potential could be realized only where pest and diseases were under control and the standard of management was very good. While this is by no means impossible it was assumed that only 70% of the yield potential is normally realized. The grower could however use his judgment regarding this item.

Items A to K in Table 1 include the results (output) of the computations and some require elaboration.

Item (B). All the sucrose yields of RVT trials were subjected to multiple regression analyses in which the following factors were considered as independent variables (X_1):

* environmental yield potential
* age at harvesting
* month of harvesting
* ratoon number
* altitude (surrogate for temperature).

The analyses produced linear equations, such as the following, which were then used to predict the sucrose yield of a variety in a given situation.

$$\text{Yield estimate} = a+bX_1+cX_2+dX_3 \quad (1)$$

where a,b,c,d are partial regression coefficients.

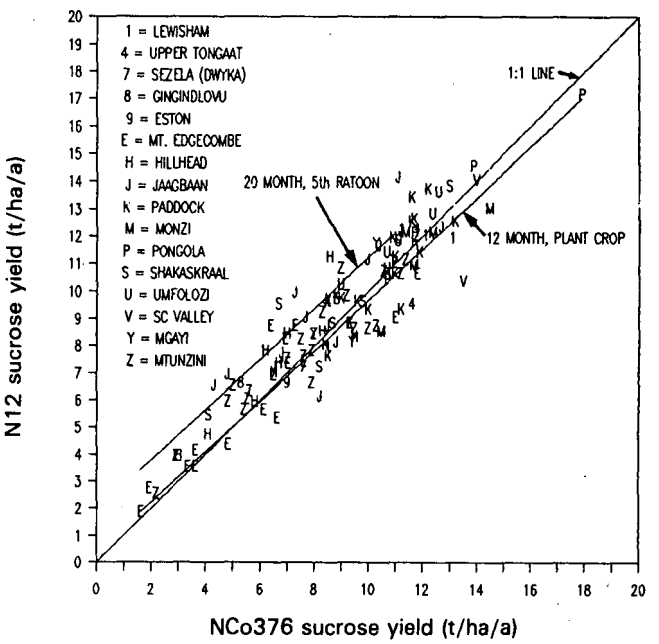

FIGURE 1 Sucrose yield of N12 compared with NCo376 growing in identical conditions.

All varieties were considered by means of scatter diagrams, such as the one for N12 presented in Fig 1. Associated with each estimate of yield obtained in this way, was a statistical error calculated using equation (2). This error, which was related to the degree of scatter among coordinates, is expected to decrease as more data are obtained from variety trials. There is a 5% probability that the estimate will be as low as the lower confidence limit (Table 1) which is derived from this error. The mean yield and the lower confidence limit were both included in the economic assessment and the corresponding mean and lower gross margins (Table 1) were both used for the variety recommendation. New varieties were thus considered with appropriate caution.

$$SE_m = SE_y\,(1/n + (x-\bar{x})^2/SSx)^{-2} \qquad (2)$$

where SE = standard errorSS
= sum of squares
m = mean
y = single yield estimate
n = number of observations
x = observed yield

Item (C). The sucrose content of each variety was divided by that of NCo376 for each of the several hundred samples taken from RVT trials. The effects of age and season on relative sucrose content were determined from multiple regression analysis. These were taken into account if significant and applicable, otherwise the mean relative sucrose content was used in the programme. The cane yield used in the calculation of haulage cost was obtained from the estimates of sucrose content and sucrose yield.

Item (D). Weed control was assumed to be necessary when more than 20% of available sunlight reached the soil surface. The duration of this period was obtained for NCo376 with the use of the sugarcane growth model, in which three weeks were allowed for germination. The germination and canopy characteristics of other varieties were considered and the period of incomplete canopy produced by the model was adjusted accordingly.

Annual weeding costs were computed as follows:

$$\text{Total weeding cost} = (12/A).(W_wT_p + W_wT_rN)/(N+1) \qquad (3)$$

where A = age at harvest (months), W_w = weekly weeding cost, T = time to 80% canopy (weeks), p = plant crop, r = ratoon crop and N = number of ratoon crops

Table 1

Demonstration of economic variety assessment programme

Climate/Soil Category:					North coast, dolerite					
1 Approx. altitude	100 m				Expected Pest and disease levels					
2 Suggested plant and harvest cycle for NCo376.					7 Mosaic low					
% area cut per annum.	85 %				8 Smut medium					
% area replanted annually	12 % (Ratoons 7)				9 Eldana high					
Fallow period	4 months				10 Weeding cost per week	20 R/ha/week				
Resultant mean harvest age	13.6 months				11 Sucrose price	400 R/ton suc.				
3 Mean sucrose % cane for NCo376	12.5 %				12 In field harvest costs	6.00 R/ton				
4 Environmental yield potential (YP)	100 t cane /ha/annum				13 Transhipment and					
	12.5 t sucrose /ha/annum				and Haulage costs	9.00 R/ton				
5 Estimated drought frequency	10 years				Total harvest cost	15.00 R/ton				
6 Management level	Good				14 Plant - weeding cost	2 000 R/ha				
% potential realized	90 %				15 Ratoon - weeding cost	500 R/ha				
Actual yield expected	90 t cane/ha per annum									
A. List of relevant varieties approved by local		1	NCo	NCo						
Pest and Disease Control committee.		1	376	310	N8	N12	N14	N16	N17	N18
B. Sucrose yield relative to NCo376 at given YP (%)		1	100	92	90	100	100	102	101	98
95% lower confidence limit (%)		1	100	92	90	97	97	100	98	90
Resultant gross return	(R/ha/annum)	1	4 500	4 132	4 050	4 485	4 489	4 596	4 552	4 410
		1								
C. Sucrose content as % of NCo376		1	100	112	90	104	100	106	107	105
Harvest and Transport cost	(R/ha/annum)	1	1 350	1 107	1 350	1 293	1 347	1 301	1 276	1 260
		1								
D. Mean time to canopy (weeks), Plant crop		1	18	16	18	20	15	15	22	
Ratoons		1	15	13	16	15	12	12	13	
Weeding cost	(R/ha/annum)	1	271	236	289	276	221	221	256	238
E. Expected number of ratoons		1	7	7	4	7	5	5	5	3
Fallow, plant and ratooning - weeding cost		1	772	759	925	772	889	895	892	1 096
F. Sucrose yield in severe drought (t/ha)		1	2.0	2.5	2.5	3.0	2.2	2.5	2.0	2.0
Loss of revenue in drought	(R/ha/annum)	1	419	355	346	372	409	408	425	409
G. Expected lodging at harvest (%)		1	26	10	51	10	13	51	51	61
Difference in harvest cost due to lodging assuming 50% extra for fully lodged cane and no additional										
cost for NCo376	(R/ha/annum)	1	0	0	75	−46	−37	76	76	104
H. Disease costs Roguing	(R/ha/annum)	1	40	40	40	0	0	40	0	0
Possible ratoons lost	No. ratoons	1	3	3	0	0	0	0	0	
Extra replant costs	(R/ha/annum)	1	0	194	669	0	0	0	0	0
		1								
I. Change in harvest age to avoid eldana (months)		1	0	0	0	1	−1	0	0	−1
Difference in plant and ratoon cost (R/ha/annum)		1	0	0	0	−68	72	0	0	87
J. Relative value of variety	(R/ha/annum)	1	1 647	1 441	357	1 886	1 589	1 657	1 626	1 215
... Possible lower value	"	1	1 647	1 441	357	1 783	1 464	1 543	1 492	855
K. Difference wrt NCo376	"	1	0	−206	−1 291	239	−59	10	−21	−432
... Possible lower value	"	1	0	−206	−1 291	136	−183	−105	−155	−792

Item (E). Ratooning ability was defined as the ability of a variety to sustain sucrose production through a number of harvest and ratooning cycles. The yield decline model used by Hoekstra[1] was not used at this stage because the association between yield and ratoon number was not clear. The number of ratoon crops expected for NCo376 was obtained from the grower's entry in item 2, and the number of ratoon crops for other varieties was an adjustment of this value based on the results of regression analysis (Item B) and on the observation that good ratooning is associated with a high stalk population and resistance to lodging and water stress. NCo376 was considered to be equal or superior to all varieties unless the regression analysis proved otherwise. The ratooning ability of recently released varieties was estimated conservatively.

The annual cost of establishing the crop was obtained by dividing the total cost of fallowing, planting and ratoon maintenance (excluding weeding cost) by the number of crops in a cycle.

Item (F). Resistance to frequent dry spells that are part of the normal growing environment was taken into account in the yield estimate of the variety (item B). Resistance to severe droughts that may occur once in 5 to 20 years was considered separately by noting the yields that have been obtained in conditions harsh enough to kill the standing crop. These yields ranged from 1,5 to 3,0 t sucrose/ha. All varieties were thus ranked on scale 1,5 to 3,0. If a severe drought was expected once in four years the most resistant variety was then credited with (1,5/4)X R/ha more than the least resistant variety if X was the sucrose price per ton.

Item (G). Lodging percentage in RVT trials was assessed visually and although the ranking of varieties according to lodging seldom changed the association between lodging and cane yield (Y) was not very clear from all the RVT results. Despite the large statistical error, equations such as the following for NCo376 were used to distinguish between varieties with different lodging characteristics and to predict the extent of lodging most likely to occur when a given yield of cane was considered.

Lodging percentage for NCo376

$$91/(1 + EXP(2.8\text{-}0.06(Y\text{-}70)) \qquad (4)$$

It was assumed that fully lodged cane would cost 50% more to harvest than erect cane, but the grower could adjust this estimate if necessary. Double accounting was avoided by considering only the difference between the cost of harvesting NCo376 and another variety.

Item (H). Varieties permitted for planting by Local Pest and Disease Control Committees often vary in susceptibility. The committees usually ensure that diseases are controlled before they affect yield significantly, so it was necessary to consider only the cost of roguing and replanting as control measures. Although the disease criteria under which these measures must be applied in practice vary considerably between regions, the programme followed the criteria given in Table 2 unless the user indicated otherwise.

The disease levels at which roguing and replanting would have to be done (Items 7 & 8) were used to estimate when these operations would occur and the costs were then computed on an annual basis.

Item (I) It was assumed that the age at harvest would be reduced for susceptible varieties so that the direct effects of eldana on yield could be ignored. The growth rate of the crop in terms of t sucrose/ha/month was assumed to be constant. Thus the effect of eldana on the cost of production was obtained from the difference (D) in annual regeneration costs that resulted from a change in the area to be fallowed, planted or ratooned each year.

$$D = 12R\left(\frac{1}{A_i} - \frac{1}{A_I}\right) \qquad (5)$$

where R = total regeneration cost per crop
A_I = harvest age (months) of standard variety (item 2)
Ai = harvest age (months) of variety i

Table 2

Time (years) after planting when infection by disease is expected to reach 10%, resulting in a plough out requirement. Roguing requirement is noted with an asterisk

Regional disease level	Variety disease rating			
	Highly susceptible	Susceptible	Intermediate	Resistant
High	3*	5*	10*	40
Medium	5*	10*	20	-
Low	10*	30	-	-

Results and discussion

The results of a typical assessment produced by the programme are given in Table 1. The results of variations between varieties in some of the agronomic characteristics are particularly noteworthy.

Table 3

Estimates of sucrose yield relative to NCo376 obtained from regression equation (1)

Potent. suc. yield (t/ha/an)			4	8	12	16	20
NCo310							
Harvest age	12		99	96	94	94	93
(months)	15		86	89	90	90	91
	18		72	82	85	87	88
N12	a)	b)					
a) Harv. age	12	4	107	100	97	96	95
(months)	12	8	114	103	99	97	96
b) Ratoon	18	4	124	108	102	100	98
	18	8	130	111	104	101	99
N14			78	94	99	102	104
N16			133	110	103	99	97
N17							
Elevation	50		132	112	105	102	100
(n)	200		108	100	98	96	95
N18			88	96	99	100	101
N19							
Harvest	April		121	112	109	107	106
month	September		98	100	101	101	102

Yield estimates produced by the regression equation (1) are presented for some varieties in Table 3. Environmental yield potential was the most significant factor affecting sucrose yield of all varieties, as was to be expected. Age at harvest was significant for NCo310 and N12. Expected number of ratoons was significant for N12, elevation for N17 and month of harvest for N19. Most varieties compared more favourably with NCo376 when the yield potential was

low rather than high. N14 and N18 were favoured relative to NCo376 by an increase in yield potential. If the sucrose price was R400/t, then the varieties listed in Table 3 may be worth up to R530/ha more than NCo376 with regard to the yield characteristic.

Table 4

Sucrose content of some new varieties relative to NCo376 and its effect on harvest and haulage costs assuming all varieties produce the same sucrose yield

Variety		NCo 310	N12	N14	N16	N17	N19	CP66/ 1043
		Sucrose content as % of NCo376						
		112	106	103	107	108	115	150
Harv/Hual cost R/t cane	Suc. yield (t/ha)	Cost saving (R/ha)						
10	6	51	27	14	31	36	63	160
10	12	103	54	28	63	71	125	320
10	18	154	82	42	94	107	188	480
15	6	77	41	21	47	53	94	240
15	12	154	82	42	94	107	188	480
15	18	231	122	63	141	160	282	720
20	6	103	54	28	63	71	125	320
20	12	206	109	56	126	142	250	640
20	18	309	163	84	188	213	376	960

Table 5

Number of ratoon crops expected for different varieties in various conditions and its effect on annual costs of fallowing, planting and ratoon maintenance

Conditions	NCo 376	NCo 310	N12	N14	N16	N17	N19	CP66/ 1043
Poor	4	4	5	3	3	3	3	2
Average	6	6	7	4	4	4	4	3
Good	8	8	9	6	6	6	5	4
Excellent	12	12	12	8	8	8	7	6
	Difference wrt NCo376 in cost, (R) per crop assuming: Fallow + Plant cost R2 800 Ratoon cost R 800							
Poor	0	0	−100	167	167	167	167	500
Average	0	0	−48	167	167	167	167	333
Good	0	0	−28	83	83	83	150	250
Excellent	0	0	0	83	83	83	119	167

The sucrose content of most new varieties exceeded that of NCo376 (Table 4) and this would benefit some growers considerably. It may be worthwhile in some cases to plant a high sucrose variety even if its yield is not equal to that of other varieties. Although sucrose content was the only quality component considered in the assessment, it may be necessary to consider the fibre and impurity components for growers who are members of cooperative mills.

Table 6

Cane yields and loging of varieties in four growth habit categories and the effect of lodging on harvesting costs per hectare assuming a cost of R6/t cane for NCo376 and a cost difference of 0.5% for each 1% change in lodging.

Cane Yield (t/ha)	Category (example) Moderate (NCo376)	Very Mild (N12)	Mild (N14)	Severe (n16)	Very Severe (N18)
	% lodging				
70	5	5	5	5	5
100	24	10	13	46	57
130	62	33	47	86	87
160	85	66	85	90	90
190	90	75	90	90	90
	Difference in harvest cost (R/ha)				
70	0	0	0	0	0
100	0	−40	−33	66	99
130	0	−112	−60	95	99
160	0	−90	0	25	26
190	0	−82	0	1	2

The approximate number of ratoon crops entered for different varieties in different conditions is given in Table 5. It could be inferred from this simple analysis that ratooning ability is not as important as is yielding ability or sucrose content, and it is possible that ratooning ability is given too much emphasis in the industry. However other factors such as discounted cash flow, availability of labour and ease of management may need to be considered.

The effects of lodging on harvesting cost is shown in Table 6. If it costs 50% more to harvest lodged than erect cane as assumed, then the benefit of an erect variety like N12 and the disadvantage of a decumbent variety like N18 may be considerable.

The cost of roguing does not have a large influence on the profitability of a variety, but the need to eradicate the crop prematurely might have a considerable effect, particularly if ratooning is weak (note N8).

Conclusions

The programme is a valuable means to channel the large amount of data captured in the research programme on released varieties for use in recommendations that are tailored to a grower's particular conditions. The method places agronomic characteristics of varieties into economic perspective and helps to minimize subjectivity in the choice of variety

REFERENCES

1. Hoekstra RG (1976). Analysis of when to plough out a sugarcane field. *Proc S Afr Sug Technol Ass* 50, 103-113.
2. Inman-Bamber NG and Thompson GD (1989). Models of dry matter accumulation by sugarcane. *Proc S Afr Sug Technol Ass* 63, 212-216.