FACTORS AFFECTING THE PERFORMANCE OF VARIETIES RELEASED RECENTLY IN THE SOUTH AFRICAN SUGAR INDUSTRY

By N. G. INMAN-BAMBER

SA Sugar Association Experiment Station, Mount Edgecombe 4300

Abstract

There are several areas in the South African sugar industry where the ubiquitous variety, NCo 376, is being superseded by newer varieties. Growers have a choice of varieties which have outyielded NCo 376 in trials under a wide range of conditions. There are others which have yielded more than NCo 376 in certain conditions. It is opportune to report the results of trials that have been conducted to investigate the agronomic characteristics of the recently released varieties. The main factors which influence the yield of one variety relative to another are fluctuations in soil moisture, season and age at which the cane is harvested, soil type, pests and diseases. Some of these factors have been deliberately varied in variety trials while the effects of others have been deduced by comparing the results of different trials.

Introduction

The amount of variety NCo 376 crushed annually has declined gradually since 1982 and the combined amount of NCo 376, NCo 310, NCo 293 and N55/805 crushed annually has decreased from 88,2 to 82,7% of the total crop (Lamusse[4,5,6]). The area allocated to new varieties in co-operative nursery schemes provides a better indication of the changes occurring in the industry. The predominant varieties in the Lowveld Nursery Scheme in the Eastern Transvaal are N14 and J59/3, which occupy 67 and 18 ha respectively while NCo 376 occupies 3 hectares (Rowland[9]). In the district controlled by the Natal Estates Local Pest and Disease Control Committee, 52 and 22% of the total area planted in the spring of 1984 was allocated to N12 and N11 respectively. NCo 293 and NCo 376 were planted on only 13 and 6% of this area respectively (Mann[8]).

Methods

Replicated field trials with commercial sugarcane varieties have been established in a number of regions in South Africa and Swaziland since 1966. The rate of release of new varieties increased after 1977 and the agronomy evaluation programme became linked to the selection and release programme. A new series of trials was established whenever two or more new varieties reached the bulking-up stage. The sites for the new series of trials were located at Pongola, on the Mtunzini propagation farm, on the Ottawa and Hillhead sections of Natal Estates, on the Paddock section of CG Smith Sugar, Umzimkulu, and at Jaagbaan. New varieties were also evaluated in trials at Nyalazi, Umfolozi and Shakaskraal. For convenience, all sites were grouped into the following regions:

Region		Code	Experimental site
Northern	northern irrigated	NIRR	Komatipoort, Mhlume, Big Bend, Makatini
	northern rainfed	NDRY	Nyalazi, Umfolozi
Coastal	coastal dolerite	DOLR	Mtunzini (SASA farm & Lawrieson Estate)
	coastal shale	SHAL	Shakaskraal, Flanders, Ottawa
Sands	coastal red sands	REDS	Beach Bush Estate (Umhlanga)
	coastal grey sands	GREY	Empangeni, Tongaat, Hillhead Estate
Upland	hinterland	HINT	Melmoth, Paddock
	mistbelt	MIST	Mowbray (Greytown), Jaagbaan

The total numbers of yield results obtained in each region for each variety are shown in Table 1. Each result was the mean of between two and six (usually three) replications. Several trials were designed to determine the effect of management factors on the performance of varieties. The mean yield of a variety at a particular level of one of these factors, eg fertilizer level, was considered as one result. For each yield result there were between one and six results for quality of the stalk and up to 18 results for height and population of stalks. The height of stalks was measured using the mean height of the top visible dewlap on any 20 stalks in a plot. NCo 376 was used in all trials and most results were expressed relative to the result of NCo 376 so that varieties that occurred in different trials, could be compared. The term 'relative' usually refers to the result of a variety divided by that of NCo 376 and multiplied by 100 to convert it to a percentage. In the case of sucrose content, 'relative' refers to the value for NCo 376 subtracted from that of the relevant variety.

TABLE 1

Number of crops (plant or ratoon) from which yield results were obtained in different regions

Regions	Variety												
	NCo 376	J59/3	NCo 293	NCo 310	N52/219	N55/805	N7	N8	N11	N12	N13	N14	N16
NIRR	173	85	11	50	126	65	22	—	20	—	6	24	6
NDRY	9	1	—	—	1	9	—	8	1	—	8	1	—
DOLR	38	10	—	18	10	22	22	18	18	8	6	8	8
SHAL	27	17	—	10	19	15	17	—	15	8	6	6	6
REDS	24	—	—	—	—	24	—	24	—	—	—	—	—
GREY	36	6	—	—	6	36	—	36	12	7	10	3	3
HINT	50	6	41	—	19	47	10	—	12	9	6	3	3
MIST	20	3	17	—	7	14	2	—	10	5	7	2	2

Results and discussion

A general comparison between a number of commercial varieties and NCo 376 was made by regressing their sucrose yields per annum on the annual yield of NCo 376 obtained from the same treatment in the same trial (Figure 1). The use of the yield of NCo 376 as a measure of the environment was justified only because at the time, this variety comprised more than 70% of the sugarcane crop in Southern Africa. The mean yield of all varieties in a trial is an acceptable measure of the environment in this kind of analysis (Eberhart and Russell[1]), but was considered to be less meaningful than the yield of the standard variety. The number of varieties in a trial seldom exceeded seven and some entries were failures so that data concerning them would have obscured environmental effects.

The high correlation coefficients (r) of N7 and N14 indicated that these varieties were dependable in that their performances could be gauged reliably from a knowledge of the performance of NCo 376 in a particular situation. The correlation coefficients of N12, N16 and J59/3 were lower, indicating that these varieties were adapted to a slightly different set of environmental conditions than those to which NCo 376 was adapted.

The relatively low correlation coefficients of N55/805, NCo 293, NCo 310, N52/219, N11 and N13 indicated that they

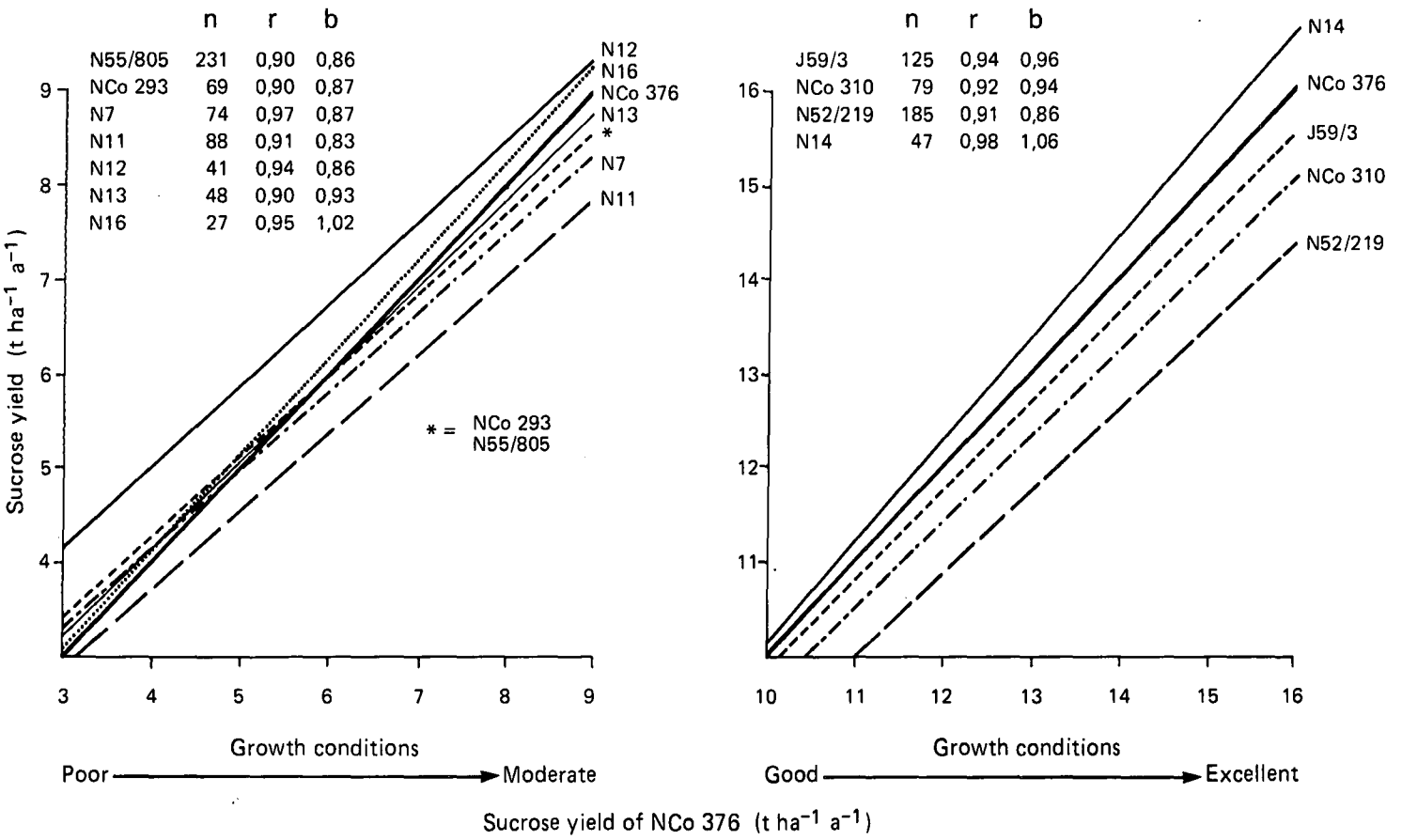

FIGURE 1 Annual sucrose yield of sugarcane varieties regressed against annual sucrose yield of NCo 376 under the same conditions. Growing conditions of (a) poor to moderate and (b) moderate to good (irrigation). n = number of observations, r = correlation coefficient, b = regression coefficient.

were fairly specific in their growth requirements or that they were fairly unpredictable. Some of the specific requirements of these and other varieties will be evident in further discussion.

Other authors have used the regression coefficient together with the correlation coefficient as a measure of the stability or adaptability of a variety (Eberhart and Russell[1], Galvanez[2], Ruschel[10]). In this investigation it was a measure of adaptability only in that NCo 376 was regarded as a highly adaptable variety.

The regression coefficient (b) was used not as a measure of adaptability so much as to identify varieties that could exploit a highly favourable environment and those which were relatively resistant to an adverse environment. The 'b' values of N14 and N16 were greater than one and they therefore appeared to be highly responsive to favourable growing conditions. J59/3, NCo 310 and N13 appeared to be fairly responsive to favourable conditions, but the other varieties appeared to be relatively unresponsive. N12, NCo 293 and N55/805 were relatively resistant to adverse growing conditions.

Ratooning ability or persistence refers to the ability of a sugarcane variety to sustain production over many ratoons and is not necessarily associated with the rate at which the ratoon develops after the previous crop has been cut. The effects of management, soil and climatic factors on persistence are probably more important than genetic factors. Nevertheless, experience gained from growing these varieties commercially has been confirmed by trial results. Consistent changes in relative cane yield over three or more ratoon crops are given as coefficients of regression of relative cane yield upon ratoon number in Table 2. Yields of plant crops tend to be misleading at times and were excluded from the analysis of ratoon results. A zero is given where no trend was evident. Changes accompanied by similar changes in relative stalk population were noteworthy. Relative cane yields of J59/3, N52/219 and N11 tended to decrease more rapidly and in more regions than those of other varieties. However, there was little change in the relative yield of these varieties in the northern irrigated region during the first four ratoon crops. Poor ratooning in N55/805 in the coastal hinterland and mistbelt was probably due to its susceptibility to rust, which was prevalent. In general, the relative yield of N8 decreased with number of ratoons. However, the yield of this variety was greater than that of NCo 376 in the grey sands, even in later ratoon crops. The ratooning qualities of N12 appeared to be as good as those of NCo 376 in all conditions except on the grey sands. In these soils, its superiority may not have lasted for more than four ratoons. N13 also ratooned well, except in the mistbelt to which it may not be well adapted. Yields of N14 and N16 in later ratoons are not yet available but N14 has consistently outyielded NCo 376 in three ratoon crops at Pongola.

TABLE 2

Relative sucrose yield (S), change in relative cane yield per crop (Δ) over a given range (R) of ratoon crops in different regions. An asterisk indicates a similar change in relative stalk population.

Region		Variety											
		J59/3	NCo 293	NCo 310	N52/219	N55/805	N7	N8	N11	N12	N13	N14	N16
Northern irrigated	S	*96*	*94*	*94*	*88*	*90*	*90*		*91*			*104*	
	Δ	-10	-1	0	-7	-1	-1		-4			0	
	R	5-7	1-11	1-12	4-7	1-12	1-6		4-7			1-3	
Northern dry	S	*90*			94	98		*87*	*104*		*102*	*97*	
	Δ												
Coastal dolerite	S	*84*		*90*	*84*	*86*	*95*	*85*	*90*	*110*	*99*	*124*	*107*
	Δ	-6		+3	-9	-7	0	-3*	-8	0	0		
	R	1-4		1-4	2-4	1-4	1-4	1-4	1-4	1-4	2-4		

Region		Variety											
		J59/3	NCo 293	NCo 310	N52/219	N55/805	N7	N8	N11	N12	N13	N14	N16
Coastal shale	S	*91*		*94*	*95*	*96*	*100*		*92*	*107*	*107*	*97*	*104*
	Δ			0	-3	0	0		0	0	0		
	R			1-3	1-3	1-3	1-3		1-3	1-3	1-3		
Red sands	S					*98*		*87*					
	Δ					0		-4					
	R					1-4		1-4					
Grey sands	S	*68*			*63*	*113*		*130*	*67*	*109*	*91*	*72*	*66*
	Δ					0		-10*		-7*	-3		
	R					1-5		1-5		1-4	1-4		
Hinter-land	S	*99*	*93*		*95*	*88*	*90*		*91*	*104*	*102*	*98*	*118*
	Δ	-4	-2		+3*	-9	+4		-13*	0	0		
	R	1-4	1-4		1-4	2-4	1-3		3-4	1-3	1-3		
Mistbelt	S	*93*	*109*		*90*	*89*	*92*		*96*	*106*	*94*	*102*	*130*
	Δ	-4	-5		-7*	-17			-12	0	-19		
	R	1-2	1-3		1-3	1-3			1-3	1-2	1-3		

Effects of season and age

The mean relative sucrose yields given in Table 2 indicate where different varieties grow best. Apart from important differences in the varieties' susceptibility to pests and diseases, the effect of the season and age of the plant may need to be considered.

Although the average yield of J59/3 was 4% less than that of NCo 376 in the northern irrigated region, it outyielded NCo 376 when harvested between March and July (Figure 2). This was probably due to the much greater sucrose content of J59/3 early in the milling season (Figure 3). J59/3 yielded well in the coastal hinterland in moderately deep soils but yielded poorly elsewhere. NCo 293 outyielded NCo 376 in the mistbelt region and in the coastal hinterland when harvested during August to October. The sucrose content of NCo 293 was greater than that of NCo 376 only at that time of the year (Figure 3). The average sucrose yield of N12 was considerably higher than that of NCo 376 in all regions considered. It appeared to be advantageous to harvest N12 during the early part of the season in the coastal region, probably because its sucrose content was substantially higher at that time of the year. N13 compared favourably with NCo 376 in the coastal dolerite and shale regions when harvested in summer when its sucrose content was high relative to that of NCo 376.

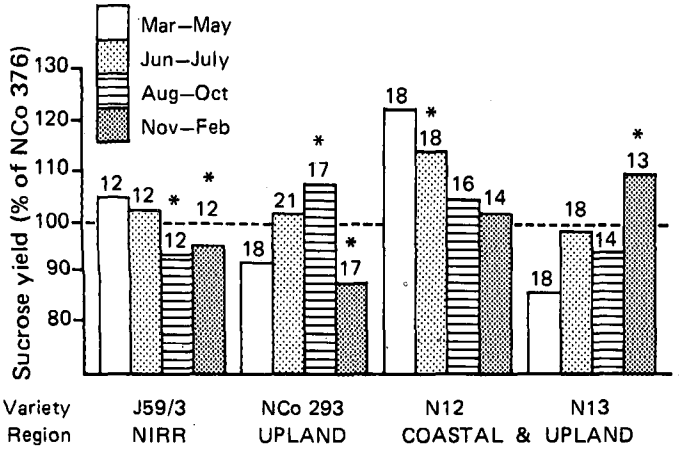

FIGURE 2 Effect of harvest season on the sucrose yield of some varieties in certain regions relative to the sucrose yield of NCo 376 under the same conditions. An asterisk denotes a statistically significant difference from NCo 376.

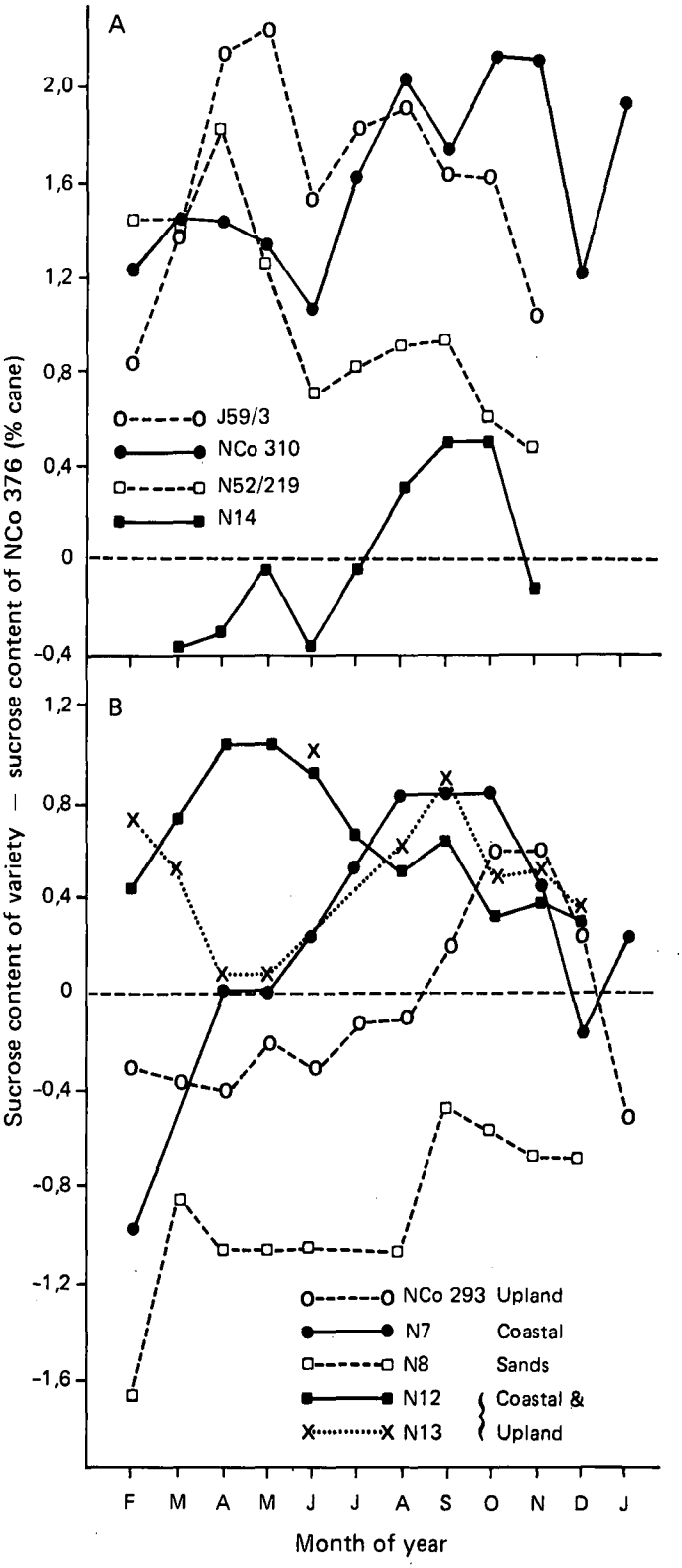

FIGURE 3 Differences between some varieties and NCo 376 in sucrose content grouped according to month of sampling (a) northern region, (b) southern regions.

In some varieties, the effect of season was evident in their relative sucrose contents but not in their relative sucrose yields (Figure 3). In the northern irrigated region, relative sucrose contents of NCo 310 and N14 were best when harvested in spring and J59/3 and N52/219 were more suited to being harvested in autumn. In the mistbelt and coastal hinterland region, the sucrose content of NCo 293 exceeded that of NCo 376 only in spring. Harvesting in spring was favourable for N7 and N13 in coastal dolerite and shale soils and for N8 in coastal sands. In all the southern areas, harvesting in autumn and winter was

favourable for N12. The results for NCo 310 confirmed those obtained by Lonsdale and Gosnell[7].

Some varieties had distinctive patterns of stalk elongation (Figure 4). In some cases, these patterns were reflected in the relative sucrose yields when harvested at different ages. N14 stalks elongated more rapidly than those of NCo 376 once the crop was 10 or more months old. This was associated with an increase of 8% units in relative sucrose yield when harvest age exceeded 12 months in the coastal region but not in the northern region. Stalks of N12 elongated more slowly than those of NCo 376 when crops were young but after six months, they elongated faster than those of NCo 376 in coastal and upland regions. In both regions, relative sucrose yields increased with the age of the crop, particularly where it was older than 18 months. In these circumstances, N12 produced 29% more sucrose per hectare than did NCo 376. A decline in the relative height of stalks of N13 in the dolerite and shale soils at the coast was associated with a decline from 108 to 94% in the relative sucrose yield when the age of the crop exceeded 15 months. Stalk elongation in NCo 293 and N11, as in N12, appeared to be more rapid than in NCo 376 in the later stages of the growth cycle in the hinterland and mistbelt regions. Relative sucrose yields increased from 86 to 96% and from 92 to 98% in NCo 293 and N11 respectively when crop age exceeded 18 months.

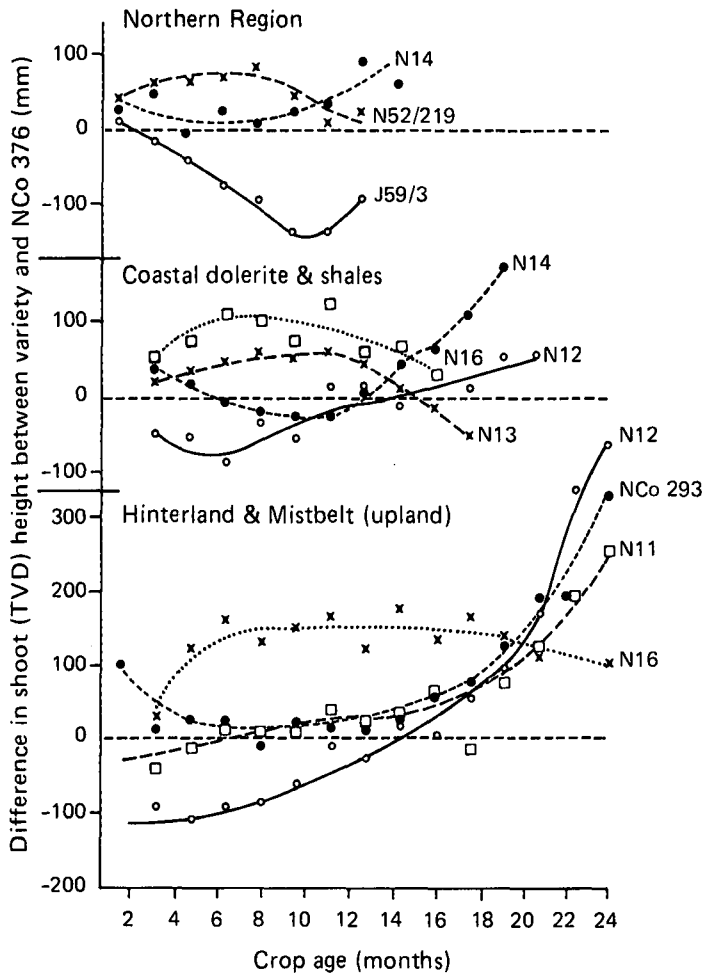

FIGURE 4 Mean difference in stalk height (measured at the top visible dewlap or TVD) of certain varieties and of NCo 376, grouped according to age and region.

Sucrose yields of N16 were significantly higher than those of NCo 376 in all the age categories considered in the coastal and upland regions, and here the difference in stalk height was maintained over a long period. N16 was more vigorous than NCo 376 initially but stalks elongated at a similar rate after about six months.

The effect of drought on commercial sugarcane varieties was apparent to some extent in the relationships shown in Figure 1a. Poor yields were largely due to drought and under these conditions, several varieties, including N7, N12 and N13, yielded more than NCo 376 did. This confirmed the observations made after the dry season in 1980 and 1981 (Inman-Bamber[3]).

The susceptibility of varieties to water stress was evident from the results of the plant crop of a trial conducted at Pongola to investigate the reaction of varieties to water stress (Figure 5). The severity of stress was such that a number of large stalks were dead when the crop was harvested 14 months after planting. The numbers of dead shoots of N14, NCo 376, N16, N12 and N13 were 9, 5, 3, 2 and 2% of the total respectively. Apart from N16, N14 yielded the most sucrose in the full irrigation treatment but it yielded the least when irrigation was suspended seven months after planting. Conversely, N12 was superior to the other varieties in the dry treatment and inferior to all but N13 in the full irrigation treatment. N13 and N16 also appeared to be better adapted to the dry conditions than NCo 376 or N14. N14 appeared to be capable of exploiting favourable conditions but had little resistance to drought. The results indicate that N16 may yield well under rainfed and irrigated conditions. The data presented in Figure 1 support this view.

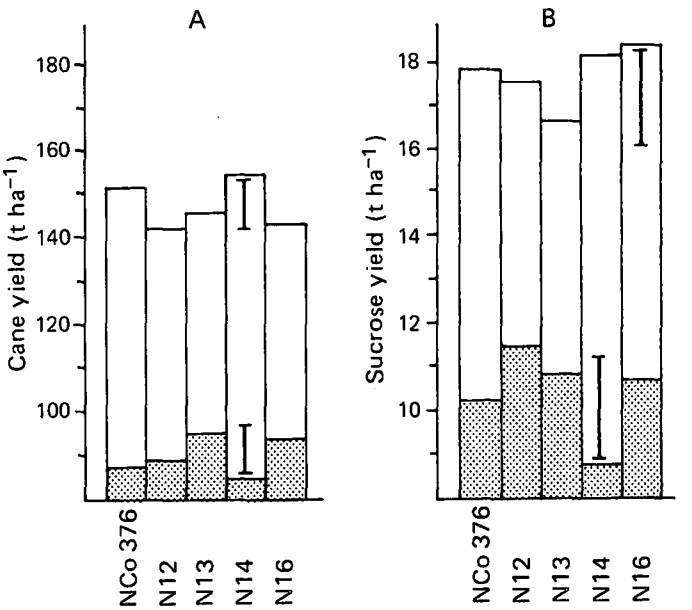

FIGURE 5 Yields of cane (A) and sucrose (B) of sugarcane varieties irrigated adequately (unshaded) deprived of irrigation seven months after planting at Pongola (shaded) I bars denote LSD (P = 0,05).

Effect of eldana borer

Varieties J59/3, N52/219 and N11 had significantly more eldana per 100 stalks than did NCo 376 in the trials at Mtunzini (Table 3). Although the mean number of eldana in stalks of N13, N14 and N16 was higher than in stalks of NCo 376, the differences between these four varieties were not statistically significant. The sucrose yield of J59/3, N52/219, N11, N13 and N16 declined as the level of eldana infestation increased. This was not the case with N14 even though it contained 30% more eldana than NCo 376 where the infestation was most severe. Yields of N14 may be less affected than those of other varieties due to infestations of eldana. Eldana numbers were relatively low in stalks of N7 and N12. The superiority of N12 was more noticeable where eldana numbers were high than where the level of infestation was low.

TABLE 3

Sucrose yield relative to NCo 376 at different levels of eldana infestation and relative eldana numbers (as a % of NCo 376) of varieties grown on a dolerite soil at Mtunzini

Level of eldana (E 100 stalks^{-1})	Variety							
	J59/3	N52/219	N7	N11	N12	N13	N14	N16
	Relative sucrose yield (% of NCo 376)							
E <15	94	91	95*	93	107*	106	—	—
E 15 to 30	78*	84	—	77	—	—	110†	135†
E 30 to 60	74	—	—	98*	133†	87	123*	99
E >60	71†	68	—	91	—	—	128*	105
All levels	Relative eldana numbers (% of NCo 376)							
	264*	312*	45*	190*	78	151	110	119

* denotes a significant difference from NCo 376 at 5% level
† denotes only one result

Conclusions

The ratooning ability of NCo 376 appears to be unsurpassed but that of N12 appears to be just as good. Several varieties may yield more sucrose than disease-free NCo 376 if they are grown under the conditions described in Table 4.

TABLE 4

Conditions under which sugar yields of certain varieties may exceed those of NCo 376

Variety	Region	Age at harvest (mths)	Harvest season	Soil water supply
J59/3	Northern irrigated	<13	Autumn	Good
NCo 293	Midlands	>18	Spring	Poor
N7	Coastal	—	Spring	Poor
N8	Grey sand	—	Spring	Poor
N12	Coastal, hinterland, midlands	>15	Autumn and winter	Poor to moderate
N13	Coastal & hinterland	<15	Spring and summer	Poor
N14	Northern irrigated	<13	Spring	Good
N16	Coastal, hinterland, mistbelt	—	—	Poor to good

Acknowledgements

Thanks are due to Messrs N Hopwood, PJ Scnetler, GE Wittig, R Poynton, M Stegen, P Hitchins and the Tongaat-Hulett and CG Smith Sugar Companies for providing land for the variety trials.

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