YIELD AND QUALITY DIFFERENCES BETWEEN IRRIGATED SUGARCANE VARIETIES

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Abstract

The yield characteristics of irrigated sugarcane varieties from the SASEX variety trials were studied to provide extension staff and growers with information on which varieties should be grown in the different agroclimatic zones.

Twelve sugarcane varieties grown under irrigation at the SASEX Pongola research station and off-station sites in Pongola, Mpumalanga and Swaziland, were compared across sites and harvesting cycles. Estimated recoverable crystal (Erc) yields were calculated for crops harvested early (Apr/May/Jun), mid (Jul/Aug/Sep) and late (Oct/Nov/Dec) season.

Generally the highest Erc yields were measured at the SASEX research station in Pongola, Komatidraai in Mpumalanga and Ubombo Ranches in Swaziland. The ranking of varieties changed slightly for different sites. The majority of varieties had the highest Erc yields when harvested early to mid season. The top ranking varieties for harvesting early season were N30, N24, N26, N25 and N32. There were no significant differences between varieties harvested mid season, although N24, N32 and N28 were the three top ranking varieties. The top ranking varieties for late season included N25 and N14. Generally N30, N26 and N24 had significantly higher Erc contents than the other varieties when harvested at any time of the year.

Keywords: yield characteristics, irrigated varieties, Erc yield, sites, harvesting cycle

Introduction

On average, one new commercial variety is being released annually for the northern irrigated regions by the South African Sugar Association Experiment Station (SASEX). A new quality payment scheme (Relative Value payment scheme) was introduced at the beginning of the year 2000 in all South African sugar mills to improve the overall quality of the sugarcane being produced by the South African sugar industry. Thus it is becoming of increasing economic importance for growers to select the best varieties for their specific environmental conditions and the best harvesting cycle. Studies on the best harvesting times for different varieties have been done before but have not included many of the more recently released varieties discussed in this paper (Rostron, 1972; Inman-Bamber, 1994; Redshaw *et al.,* 1999; Rostron *et al.*, 1999).

Currently there are 15 varieties gazetted for cultivation in the Malelane, Komati and Pongola mill areas. The cyclical transition from one major variety to another since the 1930s has been discussed previously on a number of occasions (Dodds, 1938; Perk, 1968; Lamusse, 1980; Redshaw et al., 1999). N14 and N19 are varieties that have contributed significantly to these three mill areas since the early 1990s. Mill data for the northern areas, including the Mhlume and Ubombo mills in Swaziland, for the past season (2000/2001) indicate that the previous trend of having only one or two varieties dominating the mill crush may be changing. Instead of only two, there were between three and five varieties contributing 85% of the total crush at each of the mills in the northern irrigated region, with the exception of the Mhlume mill. The remaining 15% comprised approximately 10 varieties. In the Pongola and Malelane mill regions there was a marked increase in the contribution from N25 (25.8 and 7.6%, respectively). While 63% of cane delivered to the Mhlume mill was the variety NCo376, no variety contributed more than 50% to any of the other mills.

To assist growers in their choice of variety, yield comparisons were made of variety trial data available at SASEX with respect to different trial sites and harvesting cycles. There is increasing interest in improving cane quality and therefore components of the stalk were also studied (sucrose, fibre and non-sucrose contents).

Methods

Data from 96 SASEX Plant Breeding and Agronomy variety trials, conducted between 1984 and 2000, on 10 sites with different soils (Figure 1 and Table 1) and climate (Table 2) were used.

Data collected from the Pongola off-station sites were combined for the final analyses to obtain a better idea of variety performance on low potential soils in the Pongola area. Harvesting cycles have been divided into three, three month periods: early (Apr, May and Jun), mid (Jul, Aug, Sep) and late (Oct, Nov and Dec) season. The number of crops used in this analysis varied for the different varieties and harvesting cycles.

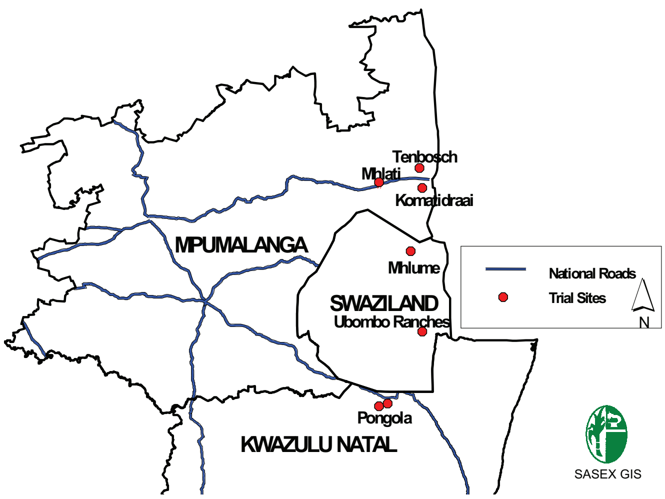

Figure 1. Location of SASEX Plant Breeding and Agronomy trial sites.

Table 1. Clay percentages and soil forms of the different trial sites (Anon, 1999).

Region	Trial site	Soil form	Clay%
Mpumalanga	Komatidraai	Shortlands	>40
	Mhlati	Shallow Shortlands	35
Swaziland	Mhlume	Katspruit	60+
	Ubombo	Deep Hutton	30-40
Pongola	Pongola - F Marx	Shallow Katspruit	35
	Pongola - P Froneman	Dundee	30-40
	Pongola - L Nel	Shallow Valsrivier	30
	Pongola - P Franck	Shallow Katspruit	30
	Pongola - P Prosch	Katspruit	8
	Pongola - SASEX	Deep Hutton	40

Table 2. Long term means for accumulated annual solar radiation and heat units for six weather stations.

Weather station	Latitude (ºS)	Altitude (m)	No. of years	Annual solar radiation (MJ/m^2)	Heat units (ºC.d) (T_b = 10ºC)
Tenbosch (for Komatidraai)	25.33	179	20	6849	4567
Mhlati	25.47	309	31	6933	4378
Mhlume	26.03	280	28	6868	4349
Ubombo	26.77	106	17	6772	4526
Pongola	27.40	308	33	6583	4089

The performance of varieties was expressed in terms of adjusted estimated recoverable crystal (Erc) yield. Seasons can influence variety yields over time (Rostron, 1972, Inman-Bamber, 1994). To make better comparisons between varieties that had been harvested in different years and at different ages, yields were normalised with respect to accumulated solar radiation. Solar radiation was derived from sunshine hours recorded at the different weather stations according to Thompson (1986) (Table 2). Due to the limited radiation data available from the Komatidraai weather station, data from the weather station located at Tenbosch were used. The recorded Erc yields were adjusted using solar radiation (Eq. 1). No account was taken of the incomplete stage of canopy development. Erc yields were calculated using cane yield and Erc content (Eq. 2). Erc content (Eq. 3) was used as a measure of relative value (RV).

$$ERCY_a = ERCY * RAD_{LTM} / RAD \quad (1)$$

$$ERCY = ERC * CY / 100 \quad (2)$$

$$ERC = a*S - b*F - c*NS \quad (3)$$

Where:

$ERCY_a$ = Erc yield adjusted for solar radiation (t/ha/an)

ERCY = Erc yield obtained for a particular variety in a specific trial (t/ha)

RAD_{LTM} = Long term mean annual solar radiation meas ured from the closest weather station ($MJ/m^2/an$)

RAD = Accumulated solar radiation measured for the duration of a specific trial and crop cycle (not intercepted radiation) (MJ/m^2)

CY = Cane yield (t/ha)

ERC = Estimated recoverable crystal content (%)

S = sucrose content (%)

F = fibre content (%)

NS = non-sucrose content (%)

a = 0.97811

b = 0.01951

c = 0.53952

When making comparisons between the twelve varieties, $ERCY_a$ data were used only when it came from four or more crops. The REML module (GENSTAT 5, 1993) was used to determine predicted means and standard error of differences for varieties at different sites and for different harvesting cycles. Two-way interactions between site and variety and harvesting cycle and variety are discussed. The three-way interaction between site and cycle with variety has not been included as there were too many combinations that had no or little data and reliable conclusions could not be made. The variables ($ERCY_a$ and Erc content) were analysed using an analysis of variance (ANOVA) table to determine the significance (5%) of the interactions between varieties and time of harvest.

Results and Discussion

$ERCY_a$

Variety comparisons in terms of adjusted Erc yield ($ERCY_a$) were made across different sites and harvesting cycles. Varieties N32 and N36 are fairly new varieties (released in 1998 and 2000 respectively) and there are limited data on these varieties. These data should be used only as a rough indication of how they could yield relative to the other varieties.

Sites

Varieties were compared across and within sites (Table 3). Generally it could be seen that some sites yielded better than others and these sites could be grouped together. Most varieties yielded higher at the SASEX research station in Pongola, Komatidraai and Ubombo Ranches than at the Pongola off-station sites and Mhlume. The difference between these high and low yielding sites could have been due to the yielding potential of the soils, possibly combined with irrigation management. Although the mean yields of all varieties at Mhlati were generally lower than those yields recorded at the three higher yielding sites this difference was not statistically significant for all the varieties.

While the ranking of varieties changed slightly for the different sites a few varieties stood out as being the highest yielding. The differences between varieties were determined by subtracting the least significant difference ($\alpha = 0.05$) from the top yielding variety at a particular site. A number of varieties could be grouped together as the highest yielding on the fertile soils of the SASEX research farm in Pongola. There was very little difference between these varieties. In ranking order these included N32, N36, N24, N25, N30, N19 and N14. The ranking of N36 might change in time when more crop data become available. N22 and N23 were the two poorest performing varieties at this site and are not suited to this site. The yield performance of varieties on the off-station sites at Pongola was generally poor with N36, N26 and N32 standing out as the top three varieties. N23 yielded very poorly at these low potential sites.

The top ranking varieties for the Mpumalanga region (Komatidraai and Mhlati) were N25 and N30. While there were some other varieties that were similar yielding to these top two varieties, their ranking differed for these two sites. N28 is not recommended for either of the Mpumalanga sites.

The top ranking varieties for the Mhlume site in Swaziland included N32, N25, N26, N19 and N24. N22 and N23 performed very poorly here and are not recommended for this site. N30 and N26 were ranked as the top two yielding varieties at Ubombo Ranches, with N24, N14 and N19 also performing well. The poor yield performance of N22 and NCo376 indicate that these varieties should not be grown at this site.

Harvesting cycles

The mean $ERCY_a$ of the twelve varieties for each season of harvest are presented in Table 4. There were significant $ERCY_a$ differences ($\alpha = 0.05$) between varieties within a harvesting period and across harvesting cycles.

When comparing the same variety across seasons it could be observed that most varieties had the highest $ERCY_a$ when harvested early to mid season (N23, N24, N26, N28, N32 and N36). N30 was significantly better when it was harvested in the early season. There were no significant differences when N14, N19, N22, N25 and NCo376 were harvested at different times of the year.

It would be more advantageous to compare varieties within a harvesting cycle as the ranking of the varieties change relative to one other when harvested at different times of the year. The top ranking varieties for planting and harvesting in the early season were N30, N24, N26, N25, N36, N32 and N19. Varieties not recommended for harvesting early include NCo376, N23 and N22. While there were no significant differences between varieties harvested mid season, the top four ranking varieties were N36, N24, N32 and N28. The top ranking varieties for the late season were N25 and N14. N23, N28 and possibly N36 are not recommended for harvesting in the late season because of their low $ERCY_a$ at this time of year.

It is acknowledged that a serious shortcoming of this study was the exclusion of ripener responses for the different varieties. There were limited data on ripener responses, with the only ripener trials being those from the Agronomy variety trials located on the Pongola research station. Ripener responses for some varieties included in this paper have, however, been discussed previously (Donaldson, 1989, 1994, 1999; and Redshaw *et al*., 1999). Generally, the best responses have been observed in the early season. All varieties discussed in this

Table 3. Mean adjusted Erc yield (t/ha/annum) of varieties, ranking and number of crops (N) at the different sites.

Variety	Pongola-SASEX		Pongola off-station		Komatidraai		Mhlati		Mhlume		Ubombo	
	Erc Yld_a	N	Erc Yld_a	N	Erc Yld_a	N	Erc Yld_a	N	Erc Yld_a	N	Erc Yld_a	N
N14	15.92^{7}	165	13.03^{5}	19	16.38^{3}	7	14.48^{4}	46	12.57^{8}	37	16.60^{4}	36
N19	16.07^{6}	124	12.96^{6}	17	16.21^{4}	7	13.74^{5}	37	13.40^{4}	29	16.36^{5}	29
N22	14.73^{11}	45	13.06^{4}	5	14.86	4	14.69^{3}	4	8.26	4	15.13	7
N23	14.32^{12}	30	10.69	7	*	0	*	0	9.85	4	15.72^{6}	4
N24	16.50^{3}	64	12.12^{10}	7	15.50^{6}	7	14.69^{3}	22	13.12^{5}	9	16.98^{3}	10
N25	16.24^{4}	41	12.73^{8}	8	17.73^{1}	7	16.07^{1}	5	13.86^{2}	7	15.24^{7}	4
N26	15.56^{8}	28	14.24^{2}	5	16.38^{3}	7	13.60^{8}	4	13.44^{3}	4	17.54^{2}	4
N28	15.36^{10}	19	*	0	14.24	6	12.33	4	12.63^{7}	4	*	0
N30	16.15^{5}	28	12.47^{9}	6	16.89^{2}	7	16.04^{2}	8	12.66^{6}	5	18.05^{1}	5
N32	16.70^{1}	18	13.88^{3}	4	*	0	13.66^{6}	7	14.42^{1}	4	*	0
N36	16.56^{2}	10	14.25^{1}	4	*	0	*	0	*	0	*	0
NCo376	15.40^{9}	174	12.89^{7}	18	15.69^{5}	10	13.65^{7}	46	12.26^{9}	37	14.66	36

LSD = 2.80 ($\alpha = 0.05$)
Where * = no (or less than 4 crops) data available

Table 4. Mean adjusted Erc yield (t/ha/annum) of varieties, ranking and number of crops (N) at different times of the year (early, mid and late season).

Variety	Early Season		Mid Season		Late Season	
	$ErcYld_a$	N	$ErcYld_a$	N	$ErcYld_a$	N
N14	15.13	100	15.38[7]	97	15.15[2]	116
N19	15.73[7]	82	15.77[5]	74	14.24	90
N22	13.73	25	14.43[12]	18	14.71	26
N23	13.40	18	14.51[11]	8	12.45	25
N24	16.62[2]	38	16.21[2]	25	14.70	56
N25	16.24[4]	26	15.76[6]	14	15.25[1]	35
N26	16.32[3]	22	15.14[9]	7	14.18	26
N28	15.33	14	15.99[4]	7	13.25	19
N30	17.30[1]	17	15.31[8]	24	14.63	21
N32	16.00[6]	12	16.14[3]	13	14.54	15
N36	16.04[5]	5	16.39[1]	12	13.49	4
NCo376	14.29	104	14.83[10]	103	14.60	114
LSD = 1.99 (α = 0.05)						

paper are known to respond to Fusilade Super ([1] personal communication). The best ripener responses have been observed in NCo376 (Donaldson, 1999). Variety N14 requires a slightly higher rate of Fusilade Super than other varieties. Under the most favourable conditions responses can vary between 2 and 4 units of sucrose % cane depending on the variety (Donaldson and Inman-Bamber, 1982). This kind of positive response to ripeners can translate into substantial sucrose yield increases (between 3 and 5 tons of sucrose per hectare have been recorded for NCo376). Varieties N19, N25 and NCo376 respond particularly well to the combination (ethephon followed by Fusilade Super) treatment (Donaldson, 1999). Some varieties respond poorly to ethephon as a single application or as a combination treatment e.g. N14, N22, N24 (Redshaw *et al.,* 1999) and possibly N26.

Cane quality

With a number of these varieties having similar $ERCY_a$ at harvest, the choice of a variety could be influenced by the quality of the sugarcane at the time of harvest. Transport and harvesting costs can be reduced when harvesting a variety that has a high Erc content. Higher economic returns could also be realised with the RV payment scheme.

Cane quality data are presented in Table 5. An analysis of variance was performed on the data to test the statistical significance of the interaction between varieties and harvesting cycle for Erc content. There were significant differences ($\alpha = 0.05$) between varieties when harvested at different times of the year.

Most varieties had significantly higher Erc contents mid to late season than in the early season. This was due to the immaturity of the sugarcane in the early season. Erc contents for the early season were however still slightly higher than expected due to the older age of the plant crops at this time of the year. N26 was the only variety that did not differ significantly in terms of Erc content for early, mid and late season. The Erc content of N23 was significantly higher in the late season than early to mid season. N25 and N28 had significantly higher Erc contents mid season than early or late season.

1 Donaldson, RA (2001), SASA Experiment Station

Some varieties had significantly higher Erc contents than other varieties when harvested at a particular time of the year. N30, N26, N24 and N36 had Erc contents significantly higher than the other varieties when harvested early season. N23 and NCo376 had the lowest Erc contents for early season harvesting. A similar trend occurred through the season for these varieties, with two additional varieties having high Erc contents mid season (N32 and N28). Although there are limited data on the new variety, N36, this variety looks promising in terms of cane quality early, mid and late season.

Conclusions

The analyses and interpretation of the trial data used in this study was fairly difficult due to the unbalanced nature of the data. This was due to the varying number of crops harvested for each sugarcane variety at the different sites and for different harvesting cycles. The overall trends for the different varieties could, however, still be observed.

This study showed that there are differences between varieties when they are harvested at different sites. Some varieties are better adapted to lower potential soils or sites than others. The irrigation management on these lower potential sites is a factor that will contribute to the final yield obtained at these sites.

It is also possible to select varieties that are higher yielding when harvested at different times of the year. While the Erc yields of some varieties may be quite similar at a particular site or for a particular harvesting cycle, it has been shown that varieties do differ in terms of cane quality.

The final choice of varieties by growers is dependent on a number of factors. Location, management practices and specific variety requirements will contribute towards this choice.

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Table 5. Harvest age, Erc content (%) and ranking of varieties early, mid and late season.

Variety	Average age (mths)			Erc content (%)		
	Early	Mid	Late	Early	Mid	Late
N14	12.8	12.2	12.2	10.55	12.49[8]	12.41
N19	12.8	12.1	12.2	11.73	13.56[6]	13.30
N22	12.8	12.3	12.2	11.04	12.30[9]	12.99
N23	12.8	11.7	12.3	9.87	11.21	12.07
N24	12.9	12.1	12.1	13.19[3]	14.85[1]	14.25[3]
N25	12.8	12.5	12.1	10.72	13.06[7]	12.16
N26	12.8	12.4	12.2	13.66[2]	13.83[5]	13.59
N28	13.1	12.4	12.0	11.55	14.09[4]	12.35
N30	13.2	12.1	12.1	13.97[1]	14.72[2]	14.48[2]
N32	13.3	12.3	12.0	11.82	14.09[4]	13.62
N36	13.8	12.0	12.5	12.80[4]	14.54[3]	14.66[1]
NCo376	12.8	12.2	12.2	9.97	12.09[10]	12.29
				LSD = 0.77 (α =0.05)		

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