TRENDS IN YIELD, SUCROSE, STALK POPULATION AND SMUT TOLERANCE OVER 20 YEARS OF SUGARCANE SELECTION IN ZIMBABWE

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Abstract

The selection programme in Zimbabwe is based on crosses made by the South African Sugar Association Experiment Station (SASEX) in South Africa. In addition varieties are imported from SASEX and Canal Point, Florida, United States of America. Data collected over 20 years were analysed to illustrate trends and the impact of selecting for high yield, high quality and smut tolerance. Cane yield showed linear and curvilinear trends but decreased marginally. ERC % cane, ERC yield and smut tolerance increased linearly in single lines. Stalk population showed linear decrease. Most of the promising varieties produced less cane, lower fibre, higher ERC % cane, higher ERC yields, fewer stalks and better smut tolerance than NCo376 and imported varieties. Implications of lower fibre in the diffuser are discussed.

Introduction

The selection programme in Zimbabwe, based on crosses made by SASEX, continues to produce promising varieties. The Zimbabwe Sugar Association Experiment Station (ZSAES) imports 100 crosses from SASEX every year. ZSAES also imports varieties from SASEX and Canal Point. The selection programme was established in 1976 to produce high yielding, high sucrose and smut resistant varieties. Low sucrose is a problem in early harvested crops (March to May). Smut is one of the major disease affecting the Zimbabwe sugar industry. Most of the imported varieties tested in Zimbabwe proved unsuitable to conditions both in yield and disease resistance, in particular resistance to smut disease.

Difficulties in application currently limit the use of ripeners in Zimbabwe (Zhou, 1996a). Selection for high sucrose is important to reduce the need for ripeners and also increase mill recoveries. Small scale growers find it impossible to apply ripeners on their farms because of problems associated with drift to non-target cane and neighbouring farms.

The selection programme has five stages: single stools, single lines, variety observation trial (VOT), advanced variety trials (AVTs) and pre-release variety trials (PRVTs). The last three stages are replicated.

Materials and methods

Data from the single lines, VOT and AVT stages of the selection programme were compiled to determine the trends in yield, sucrose, stalk population and smut tolerance over the past 22 years of selection.

The single line stages were established from selected stools and planted in non-replicated two row plots. The plant crop was harvested and weighed, and sucrose samples were analysed using the Java Ratio method. The ratoon crop was used as cane seed for the VOT stage.

The VOT trials were planted in two or three replications. Both plant and first ratoon crops were harvested and weighed and sucrose samples analysed. Smut susceptibility and smut inoculation trials were also established at the same time. Stalk population data were not collected in single lines and VOT.

Two AVTs were planted, one in the early season (AVTE, June) and the other in the late season (AVTL, September). The trials were harvested up to the third ratoon, with sucrose samples being analysed for every crop. Millable stalk counts were recorded at harvest in the advanced variety trials.

Smut and other diseases were recorded in all trials until harvest or until lodging prevented access to plots.

Fertiliser application was based on soil analysis and stage in crop cycle. Ratoon crops received more nitrogen than plant crops because of faster growth. Nitrogen, phosphorus and potassium were applied as ammonium nitrate, single superphosphate and muriate of potash respectively. The soil type was a sandy clay loam derived from paragneiss.

Means of each trial series for single lines, VOT and AVT were calculated for cane yield, ERC % cane, ERC yield and smut infection. Stalk population data were available only for AVT trials. All data except for smut infection were expressed as a percentage of NCo376. Correlations for year of selection, (trial series) and the various characteristics were analysed using the MSTAT version 4 computer program. Scatter diagrams of the data were done using Lotus 123.

Results

Cane yield showed a significant negative correlation with year of selection (P=0,01) in VOT and a positive correlation (P=0,07) in late planted AVTL. At the other stages, cane yield showed a low but insignificant positive correlation. Scatter diagrams for single lines and AVTs showed a non-linear or curvilinear trend (Figures 1 and 2).

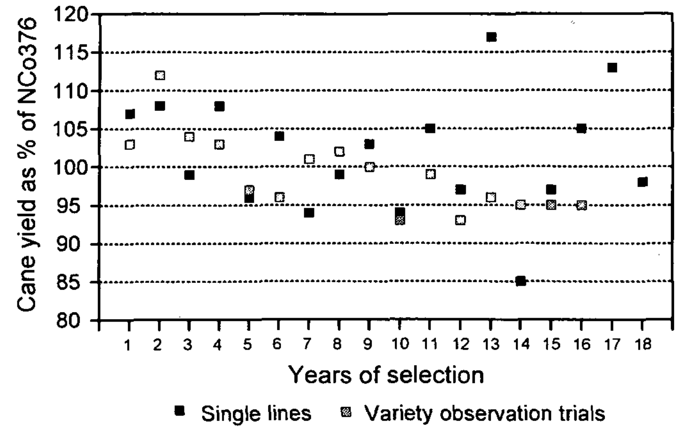

Figure 1. Cane yield (% of NCo376) from single lines and variety observation trials.

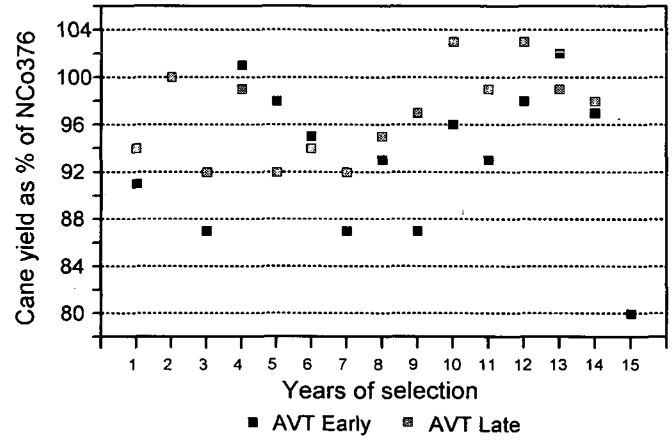

Figure 2. Cane yield (% of NCo376) from early and late advanced variety trials.

ERC % cane showed a highly significant positive correlation over the 22 years of selection. It was significant (P=0,01) in single lines, VOT and AVTL and (P=0,05) in the AVTE. The trend was linear (Figures 3 and 4).

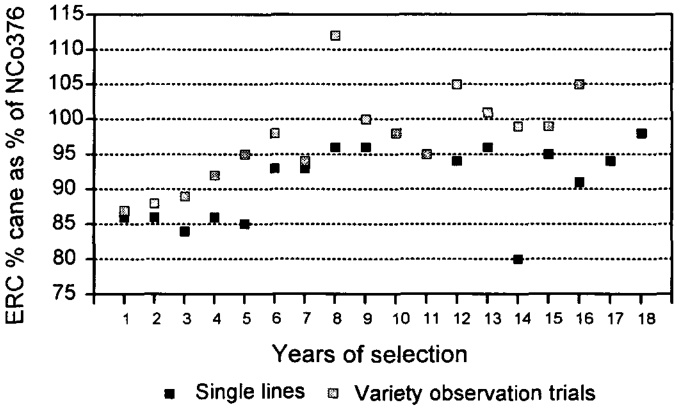

Figure 3. ERC % cane (% of NCo376) from single lines and variety observation trials.

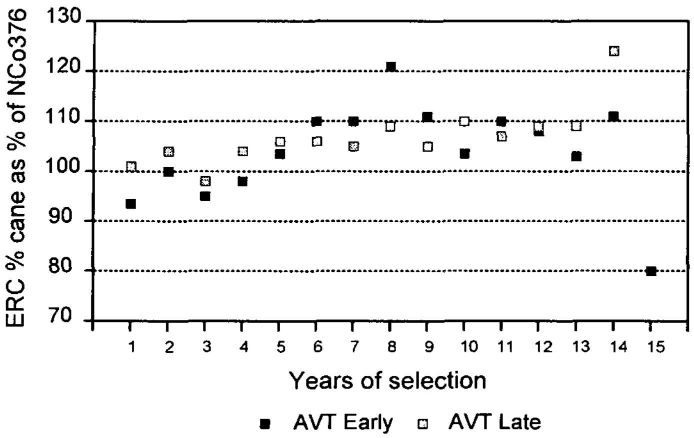

Figure 4. ERC % cane (% of NCo376) from early and late advanced variety trials.

ERC yield was positively correlated with years of selection and was significant in single lines and AVTE (P=0,05), and in AVTL (P=0,01). VOT selections were significant at P=0,065. The trends were linear (Figures 5 and 6).

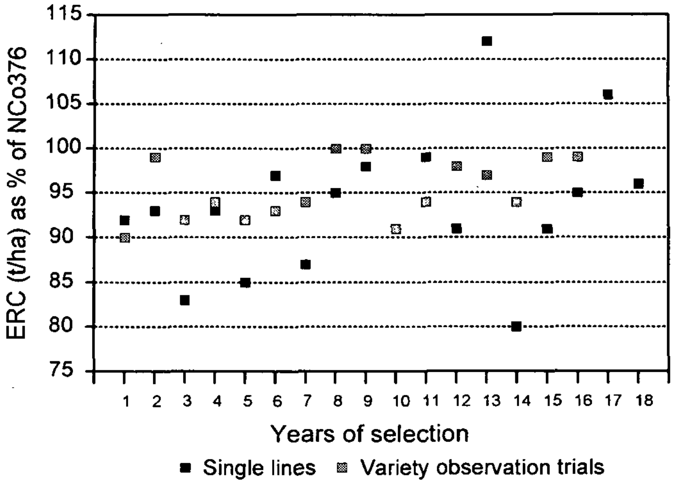

Figure 5. ERC (t/ha) from single lines and variety observation trials (as % of NCo376).

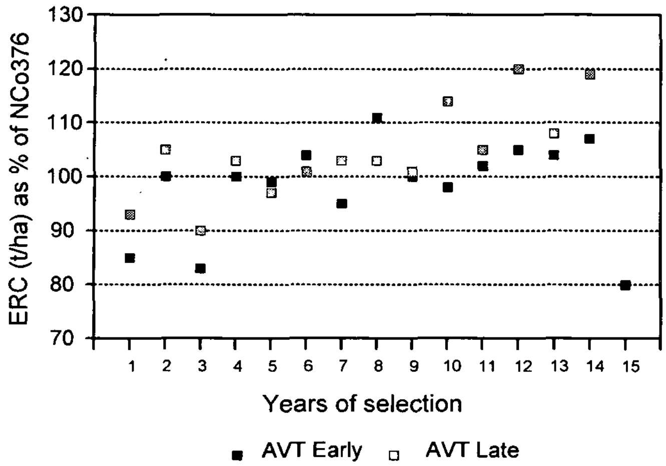

Figure 6. ERC (t/ha) from early and late advanced variety trials (as % of NCo376).

Stalk population was negatively correlated with year of selection, and the correlation was significant in AVTE (P=0,01) but not significant in AVTL. The AVTE data were more linear than the AVTL data (Figure 7).

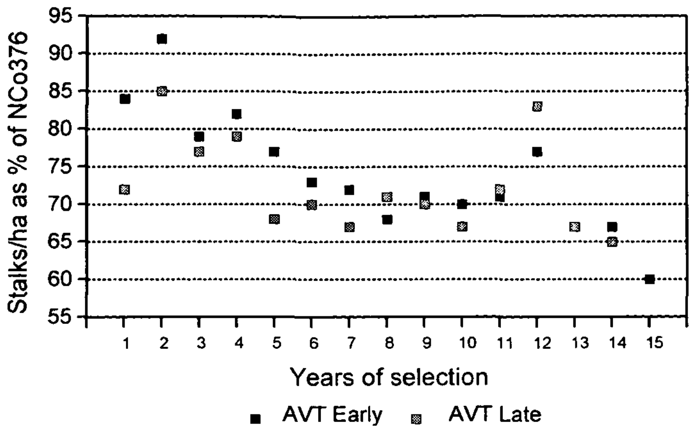

Figure 7. Stalks/ha (% of NCo376) from early and late advanced variety trials.

There was a positive correlation between smut and year of selection but this was only significant in single lines (P=0,05) and showed a linear trend (Figure 8). The more advanced stages were not significant and there were no trends.

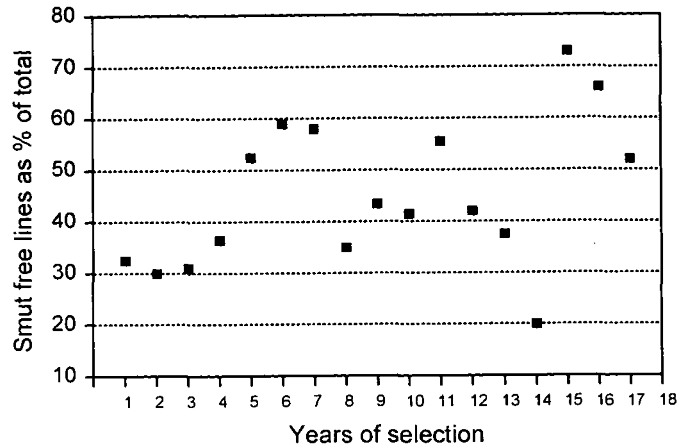

Figure 8. Smut free lines (% of total) from single lines.

Table 1. Correlations: single lines.

Variable	Correlation	Slope	Intercept	T-value	Probability
Cane (t/ha)	0,045	0,059	102,06	0,173	1,000
ERC % cane	0,742	0,696	85,79	4,288	0,000
ERC (t/ha)	0,514	0,723	87,85	2,324	0,034
Smut	0,588	1,613	32,35	2,717	0,016

Table 2: Correlations: variety observation trials.

Variable	Correlation	Slope	Intercept	T-value	Probability
Cane (t/ha)	−0,752	−0,797	105,78	4,268	0,000
ERC % cane	0,689	0,969	89,08	3,553	0,003
ERC (t/ha)	0,471	0,331	92,63	1,997	0,065
Smut	0,040	0,196	30,89	0,137	1,000

Table 3. Correlations: advanced variety trials (early).

Variable	Correlation	Slope	Intercept	T-value	Probability
Cane (t/ha)	0,205	0,253	92,75	0,724	1,000
ERC % cane	0,588	1,059	97,48	2,516	0,027
ERC (t/ha)	0,646	1,189	90,58	2,929	0,0112
Stalks/ha $*10^{-3}$	−0,803	−1,398	85,48	4,661	0,000
Smut	0,332	0,730	2,87	1,221	0,245

Table 4. Correlations: advanced variety trial (late).

Variable	Correlation	Slope	Intercept	T-value	Probability
Cane (t/ha)	0,497	0,455	93,52	1,982	0,070
ERC % cane	0,769	1,088	98,77	4,172	0,001
ERC (t/ha)	0,782	1,629	92,14	4,343	0,000
Stalks/ha $*10^{-3}$	−0,418	−0,626	77,05	1,593	0,137
Smut	0,072	0,075	3,46	0,149	1,000

All promising varieties except 85-2072 produced similar or less cane yield than NCo376. The promising varieties produced higher ERC % cane and higher sugar yields than NCo376. They all produced fewer stalks and fewer smut whips than both N14 and NCo376.

Table 5. Performance of promising varieties (% NCo376).

Variety	Cane (t/ha)	ERC% cane	ERC (t/ha)	Stalks/ha	Smut whips/ha
83-95	100	113	112	85	5,0
84-1444	97	111	107	73	1,0
85-2072	108	110	118	67	0,4
85-3328	99	115	113	72	2,4
CP72-2086	99	114	113	59	0,4

Discussion

The cane yield of VOT data showed linear trends, whereas single lines and AVT data were curvilinear (Figures 1 and 2). For the single lines and AVT data, the decline occurred in the first seven to eight years of selection and thereafter there were upward trends. These trends could be a result of a change in selection emphasis from that used initially, when all varieties with less sucrose than NCo376 were discarded.

Sucrose content and cane yield were negatively correlated. The upward trend after eight years might also have been due to the introduction of ZSAES selections as parents for the crosses, which might have improved the combining ability for cane yield. These fluctuations also indicate the difficulty of selecting for cane yield, which is highly influenced by seasonal variations. The data might also indicate that the cane yields of the selections fluctuate more from season to season than that of NCo376.

There might be a possible confounding effect of season x variety. The yield of the control (NCo376) was fairly consistent from year to year. In years where there was a shortage of water, NCo376 was less affected than most of the seedlings. Year to year variations may have introduced confounding effects due to variety x season interactions.

ERC % cane and ERC yield showed linear upward trends with year of selection (Figures 3, 4, 5 and 6). This might indicate that it is relatively more effective to select for ERC % cane and ERC yield than for cane yield. The data might also mean that, even if fluctuation with season does affect ERC % cane and ERC yield, the relative performance of varieties compared to NCo376 does not change significantly.

Stalk populations showed a linear decline that later stabilised and showed signs of increasing (Figure 7). The first eight years showed a linear decline. This might have been due to selection of thick stalked varieties that had fewer stalks. Stalk size and stalk population are negatively correlated. The stabilising could mean that stalk populations lower than the current levels would reduce yield.

Smut data showed that selection for smut tolerance is more effective at early than later stages. The number of smut free lines continued to increase with year of selection, probably due to the introduction of local selections in the crosses which were more resistant to smut.

Low fibre in promising and recently released varieties has been evident in the programme. The two recently released varieties, ZN1L and ZN2E, with fibre contents of 96 and 84% of NCo376 respectively, have resulted in poor percolation and flooding of diffusers. Variety ZN2E, with the lower fibre, caused the worst flooding. The low fibre in Zimbabwe varieties might be due to selection for high sucrose.

Conclusions

The results showed that cane yield had both linear and curvilinear trends with year of selection. ERC % cane and ERC yield increased linearly with year of selection. Stalk population showed a curvilinear decline which later stabilised. Selecting for smut tolerance was more effective in the single lines than at the later stages of selection.

The most promising varieties confirm the above trends. Most of these varieties have relatively low cane yields, high ERC % cane, high ERC yields, low stalk populations and high smut tolerance.

Acknowledgements

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