# COMPARISON OF A SERIES OF VARIETIES AT TWO HARVEST AGES

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**Abstract**

Yields of 22 varieties in the Mount Edgecombe selection programme were examined at two cutting times, 10 months in September and 17 months in April. Two methods of measuring yield at the different ages are described and the merits of the two procedures are discussed. Variety ranking based on cane yield tended to be similar for both harvest ages, although some varieties deviated significantly from the trend. The rank order based on estimated recoverable sugar content or mass of recoverable sugar per hectare differed markedly at the two harvest times. These differences are examined in terms of other cane quality components, the incidence of eldana and the degree of flowering.

## Introduction

Unlike many crops that have a clearly defined harvest period, sugarcane may be harvested at various ages and at different times of the year. In a sugarcane yield trial, with conventional harvesting methods, yield can be measured only once. Strictly, results are applicable only to the crop measured. A certain degree of extrapolation outside these limits may be acceptable: but in a variety selection programme, extrapolation may be invalid because of possible differences in the individual genotype X environment interactions of the different varieties. In the Mount Edgecombe variety selection programme, routine pre-harvest samples are taken to measure differences in cane quality at different times of the year. Attempts to estimate interim crop yields, using stalk mass derived from these samples and a population estimate, have been made in the past. However, there are large errors associated with this type of estimate, particularly with the estimate of stalk mass. Consequently, there have been few experiments in South Africa to analyse differences between varieties harvested at different times. A trial was therefore carried out to compare the yields of a group of varieties, harvested either at 10 months of age in spring or at 17 months in autumn in the following year.

## Methods

The second ratoon crop from a trial at La Mercy farm was chosen for the investigation. The trial contained 20 varieties derived from the five dryland selection programmes. Five of the varieties were selected using a 14 month cropping regime, and 15 were from selection programmes with a longer cropping cycle. Two standard varieties, NCo376 and N12, were also included in the trial. The trial had three replications and the plots consisted of five rows each of 8,0 m long and 1,4 m apart in a 5 x 5 lattice design.

Two methods of assessing the yield were followed. The first was a sample harvest based on an estimate of stalk population and mass per stalk, and the second was based on harvesting part of each plot.

### *1. Sample Harvest Method*

The first ratoon had been harvested in November 1987, and in July 1988 when the cane was eight months old, stalk population was estimated in a 2 m section of the fourth row of the plot. A sucrose sample was taken on 29/9/88. Details of the procedure are given below in the description of the plot harvest procedure for parts of plots. An estimate of stalk mass was obtained from this sample and cane yield was determined as the product of the estimated stalk population and the estimated stalk mass. A second sucrose sample was taken on 10/4/89, and from the original estimate of stalk population, the April yield was calculated.

### *2. Part Plot Harvest Method*

Sucrose samples were taken from rows four and five of the plot when harvesting took place in September, and from rows two and three in April. Rows four and two represent the net plots for the two times of harvest respectively. The sample consisted of 14 stalks, seven from each row, taken at points 2 m and 4 m respectively into the plot. The sampled rows were then harvested and weighed. It was not possible to enter the field with the weighing rig in September, because three rows of cane remained uncut, so the cane was carried from the field by hand for weighing. This constraint did not apply to the April harvest when the remaining three rows were harvested. Weights were recorded individually for each row.

The trial was rated for the degree of flowering in September 1988 and again in January 1989. The rating was on a scale from two to eight, two representing profuse flowering and eight representing varieties with no flowering. In January 1989 stalk length and stalk diameter were measured and ratings made to estimate cane erectness. When these ratings were being made, signs of drought were noticed in the trial and a rating was done to record the apparent drought stress in the different varieties. This was also on a two to eight scale, with two representing the most severely droughted and eight the least droughted.

An assessment of eldana damage was made at both times of harvest. In each case a random sample of twenty stalks was taken from the net row of the plot and each stalk split longitudinally with a knife. The number of reddened internodes was recorded.

## Results

### *Comparison between sample harvest and part plot harvest*

Measures for comparing the two methods of yield estimation are shown in Table 1. The degree of genetic determination was calculated according to Murdoch (personal communication) from the analysis of variance (F) ratio, where degree of genetic determination = F-1/F. The degree of genetic determination is a measure of the extent that a trait is genetically, rather than environmentally, determined. According to the sample harvest yield estimate in April, only 16% of the differences between varieties was of genetic origin, whereas with the part plot harvest 73% was ascribable to the variety. In the sample harvest, both components of yield (population and stalk mass) had a low degree of genetic determination, confirming that the routine sample harvest for cane quality cannot be used to provide a reliable estimate of cane yield. Except in the final ratoon crop of a trial, the part plot harvest method is impractical, owing to residual effects on the following crop, as a result of hárvesting parts of each plot at different times.

**Table 1**

**Statistical information to compare sample harvest with part plot harvest method of yield estimation**

| Source | Harvest 27/9/88 C.V.% | F-ratio | DGD* | Harvest 26/4/89 C.V.% | F-ratio | DGD |
|---|---|---|---|---|---|---|
| Gross plot (2/3 rows) | 12,5 | 3,8 | 0,74 | 11,1 | 3,7 | 0,73 |
| Net plot (1 row) | 12,8 | 3,7 | 0,73 | 13,5 | 3,0 | 0,67 |
| Sample harvest | 27,2 | 1,2 | 0,16 | | | |
| Cane analysis (ERS%) | 4,0 | 9,4 | 0,89 | 8,0 | 4,8 | 0,79 |
| Eldana (Int. red) | 85,2 | 1,7 | 0,41 | 46,0 | 3,1 | 0,68 |
| Stalk length | 7,0 | 3,5 | 0,71 | 7,2 | 1,4 | 0,29 |
| Population | 22,6 | 1,6 | 0,38 | - | - | - |
| Flower rating | 16,8 | 10,1 | 0,90 | 10,6 | 15,5 | 0,94 |
| Erectness rating | - | - | - | 12,3 | 5,2 | 0,81 |
| Drought rating | - | - | - | 10,7 | 2,6 | 0,62 |
| Mass ers (gross) | 11,8 | 4,3 | 0,77 | 12,4 | 4,6 | 0,78 |
| Mass ers (net) | 12,2 | 4 | 0,75 | 16,1 | 3,3 | 0,70 |

* DGD = degree of genetic determination

*Crop details and statistical information*

In the following comparisons cane yields obtained from the part plot harvest have been used. The mean cane yield for the trial increased from 70 tons in September 1988 to 98 tons in May 1989. This represented an accumulation of 7,0 tons cane per hectare per month for the earlier harvest but only 5,8 t/ha/month for the later harvest. Expressed in terms of tons cane per hectare per 100 mm effective rainfall these figures are 8,98 and 6,76 tc/ha/m respectively. However, there were individual varieties in the trial that maintained a steady growth rate throughout the period, e.g. 77L0424 gave a constant growth rate of 6,6 t/ha/month at both times of harvest.

Since there may be large differences in moisture content in cane harvested at different times of the year, growth is more accurately measured as dry matter accumulation. The dry matter content of the trial fell slightly, from 31,3% in September to 29,6% in April. The rate of dry matter accumulation was 1,06 t/ha/month for the 10 month old cane and 0,92 t/ha/month for the older cane.

The average estimated recoverable sugar % cane (ers) decreased from September to April, from 13,1% to 10,4%. Juice purity for the trial fell from 91% to 88,3% over the same period. The F ratios, from the analyses of variance for the two times of harvest, were generally high for cane quality parameters. This indicated that the trial was successful in detecting differences in quality between varieties, both in September and April. The F ratio for juice purity in the September harvest was low, but this was the result of the invariably high juice purity of all the varieties at the September harvest.

In September the average sucrose yield for the trial was 9,2 t/ha while in the following April this had risen to 10,2 t/ha. Although sucrose content had dropped substantially by the April harvest, the additional cane growth during the intervening period resulted in an increase in sucrose yield per hectare. However, there was a decrease in tons sucrose per hectare per month from 0,9 in September to 0,6 in April, so the older crop was less productive.

*Analysis of yield differences*

An analysis of variance of the differences between the two harvest dates was carried out and the relevant statistical values are given in Table 2. The estimate based on the yield of one guarded row per plot gave a DGD of 0,47, indicating that approximately half the difference in yield was of varietal origin. Increases in cane yield between September 1988 and April 1989 ranged with variety from 12 t/ha to 50 t/ha. Seasonal differences in ers content were strongly genetically determined, variety accounting for 84% of the differences. The decrease in ers in individual varieties ranged from 0,2 units to slightly over 5,0 units. These varietal differences did not appear to be associated with the amount of eldana damage, which was slight even at the later harvest, but there was a relatively strong correlation with the degree of flowering ($r = 0,69$). Non-flowering or shy-flowering varieties such as 77L1644 and 76W0180 showed only a small decrease in ers content, but profuse flowering varieties, such as 76W1154 and 77M1377, showed large decreases in sucrose content.

**Table 2**

**Table of differences between September and April Harvest**

| Variety | Cane Net | DM %C Diff | FIB %C Diff | Purity Diff | Ers %C Diff | Eldana Int Red | HT (CM) Diff |
|---|---|---|---|---|---|---|---|
| 76E0019 | 20 | −2,6 | 0,6 | −5,0 | −3,8 | 1,30 | 22 |
| 76E0234 | 39 | −1,9 | 1,8 | −0,7 | −4,3 | 0,20 | 17 |
| 76H0257 | 16 | −3,3 | −0,1 | −5,1 | −2,4 | 1,48 | 7 |
| 76H0333 | 15 | −1,8 | 0,8 | −5,0 | −3,3 | 1,77 | 32 |
| 76W0180 | 28 | −1,3 | 0,7 | −0,7 | −2,0 | −0,98 | 22 |
| 76W1154 | 30 | −3,1 | 1,0 | −5,6 | −4,6 | 1,37 | −2 |
| 76W2150 | 17 | −2,1 | 0,7 | −1,3 | −2,7 | 0,80 | 13 |
| 77L0424 | 50 | −3,0 | 0,1 | −0,8 | −2,7 | 0,27 | −23 |
| 77L0440 | 12 | −2,1 | −0,2 | −5,0 | −2,6 | 0,88 | 13 |
| 77L1143 | 30 | −0,9 | 1,6 | −3,0 | −2,8 | 1,03 | 17 |
| 77L1307 | 39 | −1,5 | 1,4 | −1,2 | −2,8 | 0,67 | 13 |
| 77L1644 | 39 | −0,5 | 0,9 | −1,2 | −1,5 | 0,50 | 18 |
| 77L1720 | 34 | −0,9 | 0,8 | −0,6 | −1,6 | 1,23 | 30 |
| 77L1893 | 34 | −1,4 | −0,6 | 0,7 | −0,5 | 0,73 | 37 |
| 77M0541 | 22 | −1,8 | 1,8 | −5,1 | −4,2 | 0,28 | −10 |
| 77M0641 | 29 | 0,9 | 1,1 | −0,2 | −0,3 | 0,98 | 45 |
| 77M1240 | 35 | −1,6 | 1,0 | −0,9 | −2,5 | 0,35 | 8 |
| 77M1377 | 19 | −4,9 | −0,4 | −7,9 | −5,2 | 0,88 | 5 |
| 77M1525 | 19 | −2,2 | 0,5 | −1,1 | −2,6 | 1,05 | 7 |
| 77M1571 | 39 | 1,3 | 2,1 | 5,0 | −1,2 | 0,38 | 10 |
| N12 | 27 | −2,8 | 0,3 | −5,3 | −3,7 | 0,41 | 10 |
| NC0376 | 22 | −1,0 | 1,2 | −1,4 | −2,3 | 0,86 | 12 |
| Selection site means | | | | | | | |
| 77M | 27 | −1,4 | 1,0 | −2,4 | −2,6 | 0,60 | 11 |
| 77L | 34 | −1,5 | 0,6 | −1,6 | −2,1 | 0,76 | 15 |
| 76H | 15 | −2,5 | 0,4 | −3,7 | −2,8 | 1,62 | 19 |
| 76E | 29 | −2,2 | 1,2 | −5,0 | −4,1 | 0,75 | 19 |
| 76W | 25 | −2,1 | 0,8 | −2,5 | −3,1 | 0,39 | 11 |
| Degree of Genetic Determination | | | | | | | |
| DGD | 0,47 | 0,76 | 0,47 | 0,60 | 0,84 | 0,00 | 0,5 |
| F | 1,9 | 4,1 | 1,9 | 2,5 | 6,4 | 1,0 | 2,0 |
| LSD 0,01 | 29,3 | 1,8 | 1,7 | 3,4 | 2,0 | 2,16 | 39 |
| LSD 0,05 | 22,0 | 1,3 | 1,3 | 2,6 | 1,5 | 1,62 | 29 |

An important consideration would be whether these differences are stable or repeatable in other independent trials. No duplicate trials were carried out to test the repeatability of these differences. However, the first ratoon crop of a variety trial at the Central Field Station (CFS), which contained the same series of varieties as the La Mercy trial, was accidentally burnt in May 1987 when the crop was 10 months old. The crop was harvested and weighed, and the following November the regrowth was cut back so that the crop could be harvested on schedule in May at 18 months of age. The differences in yield between these two harvests were calculated for each variety in the CFS trial and are a measure of the increase in cane yield from 10 months of age to 18 months. These figures were then compared with the increases in yield obtained in the La Mercy experiment. There was a fairly good correlation between the two trials (r = 0,48), suggesting that the pattern of yield increase from 10 months of age to 18 months tended to be consistant for each variety. This comparison is shown graphically in Figure 1.

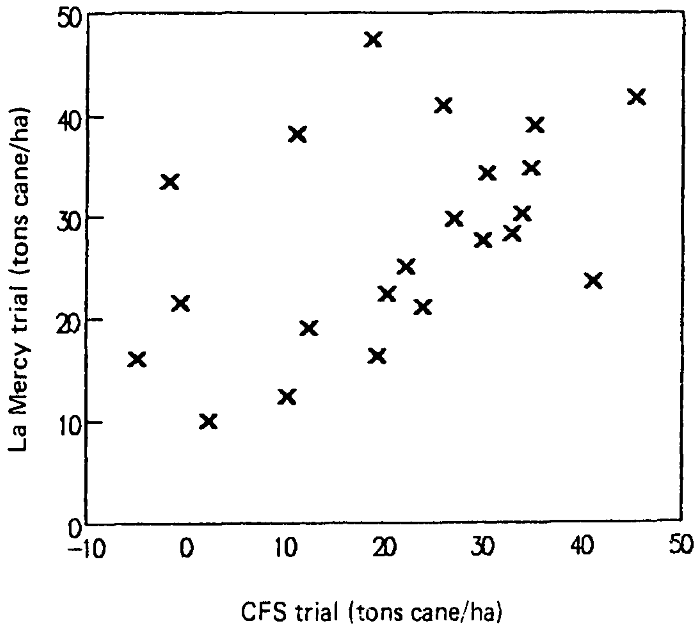


**FIGURE 1** Comparison between two harvest ages. Yield increase from 10 to 18 months.

The differences in yield were grouped according to the original selection site of the varieties and means obtained for these groups. The means for most of the sites were similar (Table 2). Varieties from the midlands programme showed a smaller yield increase than the other groups. However, there were only two varieties in this group and the result was not statistically significant.

*Comparison between September and April harvests*

Correlations for yield, quality, eldana damage and agronomic traits were calculated between the two harvest times and the coefficients are shown in Table 3. The correlation for cane yield was r = 0,63, showing that the September cane yields were a good indication of the April yields. However, as has been shown in the analysis of differences, it was possible to demonstrate variation between varieties in the mass of cane accumulated during the seven months between the harvests. There was no significant correlation between the degree of erectness, flowering or eldana damage, and the differences in cane yield from one harvest to the next. A reduced growth rate in older cane has been ascribed to lodging and consequent loss of canopy (Rostron[4]). Although cane growth was slower in the older cane than in the 10-month crop in this trial, it was not possible to associate this with lodging. The degree of flowering did show a slight correlation with yield differences (r = 0,41), but this association was not evident in the September rating for flowering. (Note that the systsem of rating used assigned an 8 to non-flowering).

**Table 3**
**Correlations between the September and April harvests**

| Sept. | April | Differences in Yield | Differences in ers %C |
|---|---|---|---|
| Height | 0,53 | 0,40 | 0,00 |
| Erectness | - | - | - |
| Flower. | 0,71 | 0,10 | 0,67 |
| Eld. dam | 0,65 | - | - |
| Yield | 0,63 | - | - |
| Ers% cane | 0,27 | - | - |
| Fibre% cane | 0,86 | - | - |
| April | | | |
| Height | | 0,15 | 0,47 |
| Erectness | | 0,11 | 0,16 |
| Flower. | | 0,41 | 0,68 |
| Eld. dam. | | 0,35 | 0,04 |
| Drought | | 0,55 | 0,26 |

According to the DGD estimate in Table 2, the differences in ers between the September and April harvests were largely determined by variety. On the other hand there was no correlation between the ers content of varieties in September and that of the same varieties in April. This may be explained by the differences between varieties in proneness to flowering. Flowering is largely a varietal characteristic, and heavily flowered varieties suffered large losses in sucrose content. These losses were large in comparison with inherent differences in sucrose content between varieties.

Differences in fibre content between the September and April harvest varied with variety, but in this case there was a strong correlation between the fibre content measured in September and that measured in April. Correlations were calculated in seven other trials that included the same varieties as were in this trial, and fibre content showed a high correlation between trials, whereas correlations between ers contents were inconsistent and generally weaker. At both harvest times fibre content was negatively associated with ers content, but the correlation was stronger in the September harvest than in April (r = −0,58 and r = −0,40). Fibre content measured in September was only weakly associated with April ers content (r = −0,22) but there was a tendency for varieties with both very low and very high fibre contents to show a greater reduction in sugar content from September to April.

*Effect of drought*

The DGD of the drought rating in January was 0,62, indicating that differences between varieties in response to drought could be detected in these ratings. There was no correlation between drought rating and the final cane yield in April, but there was a relatively strong correlation between drought rating and the difference in cane yield between September and April. (r = 0,55 ). Dry matter accumulation during the period between harvest times can be assessed by comparing dry matter per hectare per month for the two harvest dates. This figure was calculated for each of the varieties in the trial and then plotted against the drought rating (Fig 2). The correlation coefficient for the figures plotted was r = −0,7.

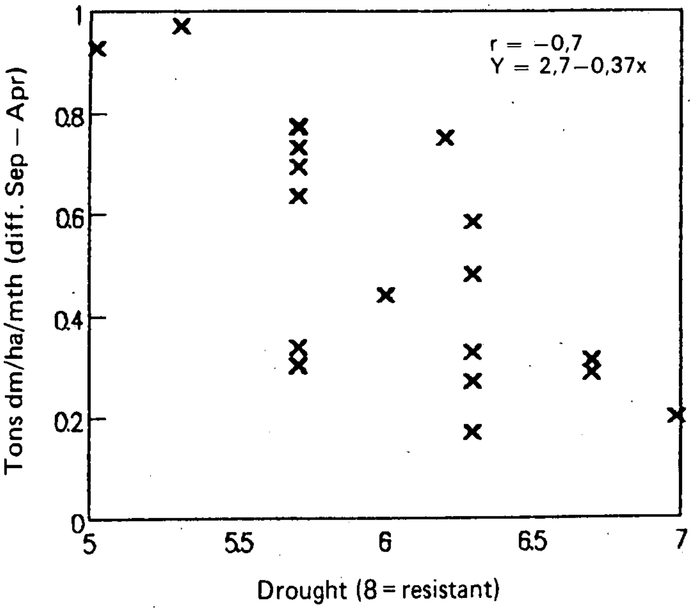


**FIGURE 2** Dry matter accumulation plotted against drought rating

cane but it is known that NCo376 quickly develops functional side-shoots after flowering. The yield of ers% cane increased from 9,2 t/ha to 10,2 t/ha. This was a decline in monthly sugar production per hectare from 0,92 t/sucrose/ha/month in the early harvest to 0,6 t/sucrose/ha/month in the April harvest.

The effect of age on the rate of cane growth is controversial. Gosnell,[1] Rostron,[4] have claimed that the rate of cane growth falls with age. More recently, it has been contended that evidence from the Field Records System[1] has supported this view. However, Inman-Bamber[3] (personal communication) disputes this conclusion, because it seems from crop modelling that the differences in rates of maintenance respiration between young and old cane are small, and in the absence of other growth constraints, old cane should grow at virtually the same rate as young cane. In this trial cane growth was slower in the older than in the younger crop, at least to some extent because of drought conditions experienced by the older cane. Although yield of 10 month old cane was indicative of that of older cane, there were real differences between varieties in their second season of growth. It therefore appears to be prudent to continue to evaluate varieties in the selection programme for both annual and standover conditions.

## Discussion and Conclusion

Under the conditions in which this trial was conducted, it would have been inadvisable to stand cane over from September to April. For the trial ers% cane was generally lower in April than it was in September, although in certain varieties it remained virtually unchanged. However, in contrast to the findings of Moberly,[2] there were no varieties that increased in sugar content in the standover crop. The decline in ers% cane appeared to be partly due to flowering, and most varieties that had flowered in the winter of 1988 suffered heavy loss of sucrose during the standover period. There were exceptions where the fall in sucrose content was slight despite heavy flowering. NCo376 was one variety where the fall in sucrose content was low relative to the amount of flowering. Nuss[3] has suggested that cane deterioration after flowering is influenced by the degree of subsequent side-shooting. No inspection for side-shooting was done on this

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