

SOME OBSERVATIONS ON THE SUGARCANE SELECTION PROGRAMME IN SOUTH AFRICA

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Abstract

Evidence from cane selection studies is considered in relation to the possibility of evaluating the selection performance of different parental combinations by means of a cross assessment trial. The evaluation is based on an estimate of the mean mass ERS for the cross, obtained from plots planted with original seedlings in a replicated layout. Crosses with an unsatisfactory assessment may be culled before entering the selection programme at the original seedling stage. The possible effect of adding a cross assessment stage to a selection programme is discussed in general terms.

Introduction

Selection experiments to examine quantitatively the improvement achieved through selecting original seedling populations were first started at Mount Edgecombe in 1969.³ Similar experiments were initiated in 1971 at the main Field Stations of the South African Sugar Association Experiment Station. It was hoped that, by carrying out the investigations under the wide range of conditions presented by the five main stations, it might be possible to infer what conditions led to the greatest advance from selection. Since the Plant Breeding Field Officers of the different field stations are responsible for the early-stage selection at their own stations, they were able to study at first hand, the various factors affecting selection.

Skinner⁹ in his review of selection in sugarcane drew attention to the possibility that, in selecting for attributes of low repeatability, a system of selection based on family selection might prove more effective than one based on individual selection. He pointed out that in many cane breeding programmes some degree of family selection is already practised as a result of using proven crosses in the breeding programme. However, before a cross can be rated as proven, many years must elapse while selection rates and cross performance in the later selection stages are determined. The time taken for this procedure may be anything from 5 to 10 years or more.

In this paper evidence is presented from various selection studies which suggest that crosses may be evaluated early in the programme through a cross assessment trial.

Experimental procedures and results

Repeatability studies

The data collected from the selection studies carried out at the field stations are in the process of being analysed, and will later be reported in detail. A preliminary analysis of some of the results shows the low repeatability of cane yields between the single stool and single line stages. This in turn indicates that the environmental influence on the expression of yield is very high in relation to the genetic effects.

Table 1 presents estimates of the degree of genetic determination⁴ of cane yield and brix derived from 4 of these trials.

The figures confirm what has previously been found on many occasions^{5,6} — namely, that the masses of individual stools are an unreliable guide to inherent yielding ability. At the irrigated stations (Pongola and Chaka's Kraal) the degree of

TABLE 1

Estimates of the degree of genetic determination and advance due to selection

| Site | Year | Degree of genetic determination | | Advance in yield due to selection |
|---------------------|------|---------------------------------|------|-----------------------------------|
| | | Mass | Brix | |
| Chaka's Kraal . . . | 1972 | 0,35 | 0,6 | 20% |
| Pongola | 1972 | 0,16 | 0,6 | 14% |
| C.F.S. | 1972 | 0,4 | 0,14 | 21% |
| Experiment Station | 1969 | 0,4 | 0,19 | 22% |

genetic determination of Brix is relatively high, but at the two dryland sites (Central Field Station and Experiment Station) this figure is rather low.

Determination of cross mean sugar content

In many cane breeding countries, selection at the single stool stage places considerable emphasis on brix determinations carried out on individual stools. In South Africa, however, selection at this stage has been primarily based on vigour. A considerable amount of effort has been devoted to investigating whether a similar account should be taken of brix during the selection of our seedlings.

In an attempt to improve selection at Chaka's Kraal the top 20% was selected from a population of 25 000 seedlings, using a visual assessment of vigour as the criterion for selection. Since our programme only caters for an 8% selection at this stage, the numbers had to be further reduced. This was done using brix as a second criterion. The brix was measured with an accumulating punch, juice samples being taken from five stalks in each stool. Brix selection was used to reduce the numbers in each cross, so that in the end approximately 8% were selected from each cross.

The mean and standard deviations of the brix readings, for the 85 crosses used in this work, were calculated. It was apparent from these figures that the standard deviation rarely exceeded 1,5 in any cross, whereas the mean brix figure ranged from 14,8 to 22,0. From these figures it was inferred that a relatively good estimate of the cross mean brix value could be obtained through punching about 20 stools taken at random.

It had been noted during the 1969 seedling observation experiment at Mount Edgecombe,³ when punch sampling with a single punch, that stalk to stalk variation was not high if obvious late tillers were avoided. It was concluded that a single mature stalk taken from 20 random stools within a cross would form a representative sucrose sample of the cross.

This procedure was carried out the following year, prior to the routine selection of single stools, at Chaka's Kraal and Pongola. Of approximately 200 different crosses planted at the two stations, 23 were in common. There was a very good correlation between the brix values obtained for these crosses at the two sites, $r = 0,86$. This is shown graphically in Fig 1.

Determination of cross mean stool mass

Encouraged by the good association shown between the brix readings, the estimated stool mass data were treated in the

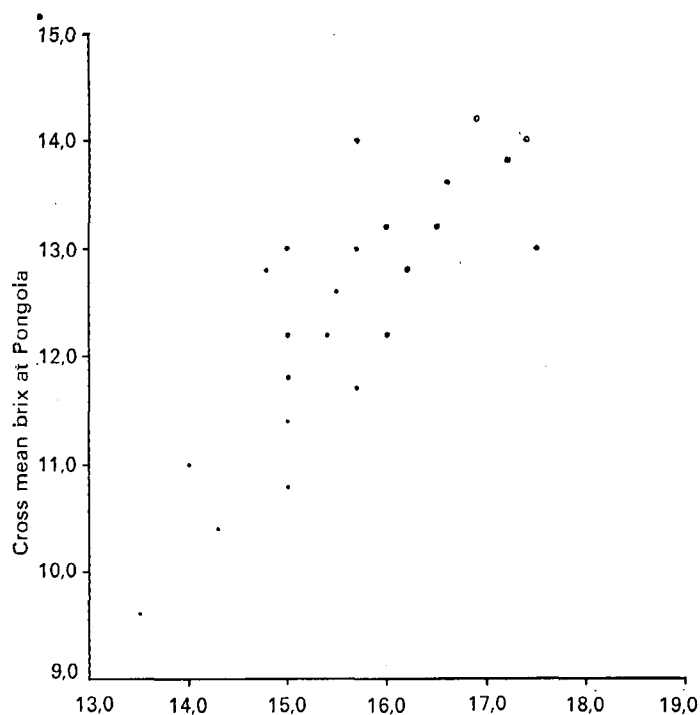


FIGURE 1 Association of cross mean brix between Pongola and Chaka's Kraal.

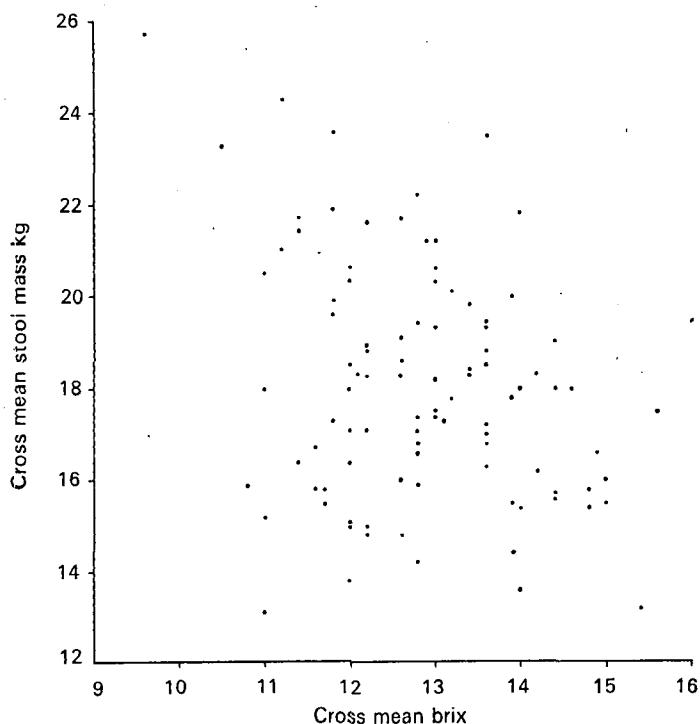


FIGURE 2 Association between cross mean stool mass and cross mean brix.

same way. The mass estimates had been obtained during selection using a formula worked out by Bechet¹ based on population height and diameter. The estimates were only made on the stools that were of selectable standard, so did not represent a random sample. The cross mean stool mass showed virtually no correlation between the sites. The reason for this lack of correlation was considered to be owing to both the variable nature of the soil, and the poor establishment of seedlings that had occurred at Chaka's Kraal. Pongola, on the other hand, was considered to be a very uniform site, where establishment at planting out had been good.

The association between the cross mean stool mass and the brix value for each cross was calculated for the Pongola data.

A significant negative correlation $r = -0,30$ was obtained and this is shown in Fig 2. This negative association bears out the common observation made during seedling selection, that very vigorous crosses tend to be low quality whilst high sucrose crosses tend to be of low vigour.

The fact that this association could be demonstrated was encouragement that the mean mass per selected stool per cross, might be a useful measure of cross performance. On the other hand, the practicality of measuring the yield of a large number of single stools was doubtful, and in any case as demonstrated by the Chaka's Kraal figures field variability could mask any cross differences. A more precise method of measuring the average stool yield of seedlings from different crosses was required before the technique could be considered further.

Skinner⁸ reported on the use of mixed variety plots to measure selection gains, and the effects of self pollination in sugarcane breeding. The mixed variety plots in the 3 replicate trial contained a number of single stool (2-sett) sub plots, each sub plot being a different variety or clone. Included in the mixed plot treatments were clones taken at random from three different crosses. The yield results showed that a population of varieties (cross) could be represented without bias by 2-sett sub plots grouped into larger plots.

The competition effects in the population were considered to add up to zero since the gain in yield from a strongly competitive variety was balanced by losses in yield by the surrounding weaker competitors. The order of merit of the 3 crosses as determined by the yield results was in agreement with the predicted performance of the crosses.

Brett² carried out a similar experiment in South Africa using original seedlings, as opposed to sett planted clones, from 5 different crosses. The performance of the crosses was sufficiently well known to make predictions as to the order of merit. The yield results are shown in Table 2 and it may be seen that the measured yield ranking follows closely the anticipated order of merit.

TABLE 2

The cane yields obtained by weighing original seedlings of 5 different crosses

| Predicted rank | Cross | Actual rank | Yield kg |
|--|----------------------------|-------------|----------|
| 1 | Control NCo 376 | 1 | 845 |
| 2 | Co 421 × Co 331 | 3 | 640 |
| 3 | NCo 310 × Co 331 | 4 | 620 |
| 4 | Co 421 × Co 312 | 2 | 680 |
| 5 | NCo 339 × Co 301 | 5 | 525 |
| 6 | NCo 293 × Co 312 | 6 | 480 |
| Least significant difference | | 5% | 75 kg |
| | | 1% | 102 kg |

Cross assessment trial

Due to the introduction of new successful crossing techniques in the glasshouse and photoperiod house, it is now possible to make approximately 1 500 crosses per annum. The field selection programme, however, is unable to provide for the confident evaluation of such large numbers of crosses, unless the procedure is modified considerably. It is in this light, together with the foregoing evidence, that the possibility of assessing crosses before entering the single stool stage of selection has been suggested.

A preliminary trial has been planted at Mount Edgecombe to study in more detail the possibility of early cross assessment. Each cross has been represented in the trial by 3

plots, each plot consisting of 2 rows containing 20 original seedlings planted at 0,5 m spacing. The normal single budded pot controls and sett planted control plots have been included in the trial.

At harvest a sucrose sample consisting of one stalk from every alternate stool will be taken, and the compounded sample will be used to estimate for each cross mean recoverable sugar content (ERS). The cane from each plot will be cut and weighed to obtain an estimate of the cane yield for each cross. The performance and order of merit of the crosses will be determined on mass ERS. The actual ranking will be compared with the predicted performance, and this will form the basis for judging the technique.

Discussion

If the cross assessment technique proves to be successful for discriminating between crosses with reasonable accuracy, thorough consideration of the implications of adding a cross assessment stage to the selection programme will have to be given. There must be a certain amount of apprehension if a move in this direction leads to a marked narrowing of the genetic base of the programme. However, the degree of family selection exercised would be controlled to an extent by the percentage of crosses allowed to enter the single stool stage.

It is pertinent to mention that in several cane growing countries, one or two crosses do account for a high proportion of the commercial varieties under cultivation. In South Africa for example, approximately 90% of the area under cane is planted to progeny of the cross Co 421 × Co 312. In Australia, many commercial varieties owe their origin to either Co 290 × POJ 2878 or Trojan × Co 475. In our current programme the preponderance of CB 40/35 derivatives in the final selection stages is striking.⁷

Unfortunately it is very difficult to examine the effects of family selection directly, since large numbers of crosses are required to obtain valid results. This in turn would involve very high numbers of seedlings, and it is usually beyond the available resources to deal with these high numbers experimentally.

It is of interest to note that, using brix data collected from single stool selection at Chaka's Kraal, it was possible to esti-

mate the effect in single lines of taking only the best 50% of the crosses, using mean brix as a criterion. This would have achieved an advance of 5,0% in the overall average ERS in the single lines, which compares favourably with estimates of advances due to individual brix selection obtained in various seedling selection studies.

Crosses, whose progeny are generally of poor performance, but which contain the occasional outstanding seedling, would presumably be rated poorly in the assessment trial. Omission of this type of cross from the selection programme may be criticised with justification, since commercial varieties have been obtained from this type of cross. On the other hand, the early selection stage is known to be a net of rather coarse mesh and promising clones can be inadvertently missed. Perhaps concentrating on crosses with a relatively high number of good seedlings would be the more efficient approach.

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