SOME OBSERVATIONS ON THE SELECTION OF SINGLE STOOLS AT MOUNT EDGECOMBE

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Abstract

The performance of approximately 300 original seedlings was compared in the single stool stage of the selection programme with their performance at the next stage (single lines). The apparent gain from selection in single stools was compared with respect to various methods of selection and different operators. The performance of unselected and selected seedlings was measured in the single line stage, and determinations of the real gain from the single stool selections were made. In the particular batch of single stools studied, using the standard selection procedure, a real gain from selection of 21,6% was achieved in mass cane. The degree of genetic determination for cane yield was 0,4.

Introduction

In all centres where sugarcane breeding is carried out, the objectives in the early stages of selection are basically similar. The breeder is initially faced with a large number of varieties, in the form of seedlings, from which the inferior material must be eliminated. Provided that he does this efficiently, he is left with comparatively few superior clones, which he may test precisely against the best current commercial varieties.

Skinner[9] after reviewing the efficiency of various selection programmes, concluded that due to the high influence of environmental factors on original seedlings performance, selection was very unreliable. He went on to show that if the then standard selection rate of 2% was adopted then most of the superior clones would have been discarded.

It may be assumed that part of the environmental variability is the result of differences in soil fertility. Consequently, if the differences in soil fertility could be reduced, then selection would be more reliable. It has been reported from elsewhere,[10] and it is a general observation locally, that soil uniformity is only obtainable at high levels of fertility. It was, therefore, decided to investigate whether an organic fertilizer — chicken manure — would reduce environmental variability in single stools.

At the same time, it was considered opportune to assess critically various aspects of the selection programme with reference to the selection of single stools.

Procedure

In September 1969, immediately prior to the routine planting of the single stools, an area 85 m long by 16 rows of seedlings was demarcated and divided into 32 plots. Each plot consisted of 2 rows by 42½ m. Chicken manure at the rate of 3 tons per hectare was applied to half the plots. This was lightly dug in, and the planting of single stools carried out following the normal procedure. Seedlings were spaced 0,91 m in the row, the rows being alternately 1,4 m and 2,8 m apart. Fertilizer in the form of Saaifos (2,5% N 8,3% P) was applied at the rate of 56 gm per seedling. After every 20 seedlings, a commercial variety grown from a single-eyed sett in a pot was planted to act as a standard. The area contained, at planting, slightly over 1 200 seedlings, and 64 standard variety stools. A plan was prepared and each seedling given an identifying number.

One and a half months after planting, all seedlings were rated on a 0-9 scale (0= dead, 9 = excellent) according to their apparent vigour. Gradings were continued at 2 monthly intervals, until final selection in November, 1970. When the seedlings were 6 months old, 2 selectors recorded their choice of seedlings at this stage.

The seedlings were selected finally at 13½ months of age and the identity of the chosen stools noted. All the seedlings were cut, topped, and their mass determined. In addition to the normal selections, a block of 320 seedlings from the area were advanced without selection to the next (single line) stage of trial. All seedlings that were advanced to single lines were measured for length and number of stalks, and Brix of a 4-stalk sample.

In order to determine whether a better appreciation of stool mass would be obtained if the stools were trashed, some 200 seedlings were visually graded for mass before and after burning.

The original seedlings were allowed to ratoon, and in the 12 month ratoon, a Brix sample on 5 stalks was taken, using a composite sample punch. A 10-stalk sample was simultaneously analysed for sucrose per cent cane using the common Java Ratio method. The mass of cane of the individual seedlings was measured, allowing for the mass of the 10-stalk sample.

The treatment of the 320 unselected seedlings together with the selected seedlings followed closely the normal procedure for the single line stage of the programme. The lines were planted in November, 1970, using the standard 8 m row length at 1,4 m spacing.

Four months after planting, NCo 376 was, rather belatedly, planted in lines where cane had failed to germinate.

At 13 months of age the number of stalks in each line was counted and a 10-stalk sample analysed for ERS using the common Java Ratio method.

In May/June, 1972, these single lines were sampled for ERS, harvested and their mass determined with the rest of the single lines. Fifty lines were chosen at random, and for each of these lines measurements of stalk length and stalk diameter were taken.

Results

Application of chicken manure

It was noted that the chicken manure adversely affected the growth of seedlings. Almost immediately after planting, seedlings that had been treated with manure showed a slightly droughted appearance. The check in growth was reflected in the grading at 1½ months, when manured plants had an average grade of 4,27 compared with 5,01 for the unmanured seedlings. At harvest, no significant difference existed between the two treatments, although the mean of the manured seedlings was slightly lower. The mean mass of stools together with the variance for the treatments and crosses is presented in Table 1.

It may be noted from these figures that both treatments yielded populations of very high variability.

TABLE 1
The effect of chicken manure on mean yield and variability of single stools

Treatment	Mass of individual stools	
	Mean	S.D.
Manure	25,6	±12,2
Control	27,4	±11,0

Note: Standard deviation calculated within plots (hence within cross) of 40 stools.

Initial Grade compared with Final Stool Mass

Early in the development of cane breeding programmes it was discovered that the appearance of the seedling at the time of transplanting to the field was not a reliable indication of its performance as a mature stool. Bregger[4] in 1932, showed that if he had discarded seedlings with fewer than 6 tillers at transplanting, then 2/3 of the varieties subsequently selected for further trial would have been eliminated. However, although selection on a basis of very early vigour is undesirable, subsequent work[2] has shown that there was a slight positive correlation between tillering in pots and first year trial performance. It was suggested that such early selection might be justified if a reduction of seedling numbers was required between potting and field nursery stages.

Figure 1 shows the relationship between grading of 1½-month-old seedlings and final stool weight, and it can be seen that in the grades below grade 4 there are very few seedlings which subsequently proved to be of selectable standard. The culling of grade 3 and below in this experiment would have accounted for 11 % of the seedlings. However, it was noted during the course of the experiment that stools that died out were invariably low grade at planting. Had these been eliminated before planting as single stools, gaps would probably have been fewer. This would have reduced competition differences between stools, which may have a very great effect on their performance.

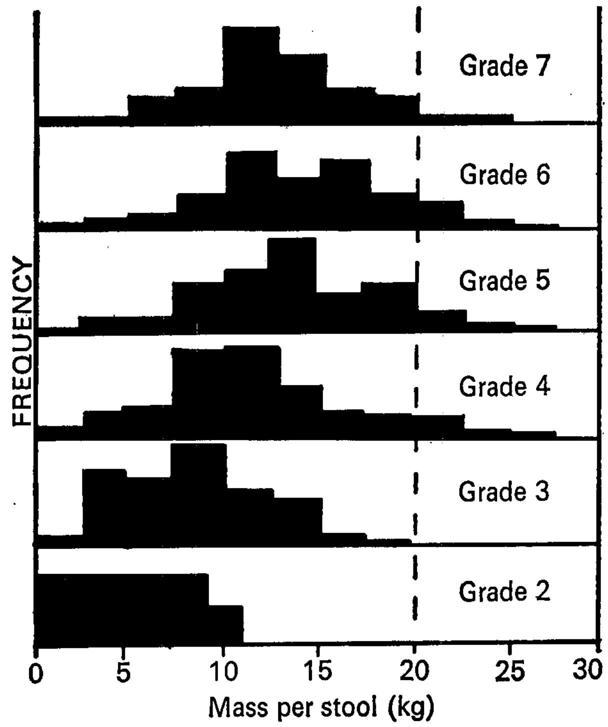

FIGURE 1: Histograms showing the relationship between initial gradings and final stool mass.

Intermediate Grades compared with Final Stool Mass

Gradings of the seedlings were carried out after every 2 months approximately and the correlation coefficients with respect to final stool mass are given in Table 2.

TABLE 2
Correlations between gradings at various stages and final stool mass

	Initial grade	Intermediate grades			
Grade date	7/11/69	30/12/69	2/2/70	21/5/70	25/9/70
Correlation coefficient	0,54	0,65	0,67	0,70	0,75

From these results it can be seen that the estimation of single stool mass by grading is relatively imprecise, and that there was little improvement in this ability in the intermediate gradings.

In Mauritius the practice has been to trash the seedlings before selecting to enable the selector to obtain a better appreciation of the seedlings. In the above experiment where the mass estimation in the burnt and unburnt cane was done there was no improvement in the correlation between estimated and actual mass, the correlation coefficient being 0,76 in both cases. It must be pointed out, however, that cane type, stalk thickness and to some extent population, was much more easily seen in the burnt cane.

Selection of Single Stools

The selection of single stools was considered from various aspects. The most important single factor in selecting single stools at Mount Edgecombe has been

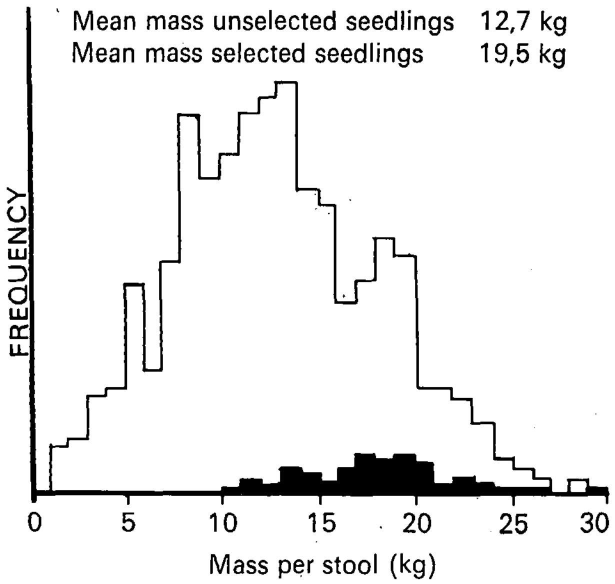

FIGURE 2: Histogram showing the relationship between selected and unselected populations of seedlings.

regarded as vigour, this being a visual assessment of stool mass. The actual performance of selectors was recorded and the results of one selector were recorded in histogram form in Figure 2.

This shows the relationship between the selected and unselected seedlings. The selected seedlings in this case represented 7,5% of the total population, i.e. the selection rate was 7,5%. The mean mass of the population was 12,7 kg per stool, and the mean mass of the selected seedlings was 19,5 kg per stool. This was an improvement of 54% on the original population, and the apparent gain may be termed the selection differential (D) (Lush[6] 1945).

Appendix A shows individual selections made by two different selectors, and these were compared with selections on mass and mass Brix. It may be seen that the choice of seedlings varied considerably between selectors and only 8 of the 24 selections were in common. However, the mean mass of the selected seedlings was almost identical, and both operators achieved the same selection differential in terms of mass cane. If the selection had been done on an actual mass basis then the mean value per stool would have been 23,2 kg per stool. (D = 82%).

Brix in Selection

The possibility of using Brix as a criterion was also considered and the mean mass Brix of grade 6 seedlings over 14,1 Brix and grade 7^+ with over 13,5 Brix was calculated. This resulted in a selection rate of nearly 10% and the mass Brix was 2,75 kg as compared with 2,71 kg for those actually selected. This suggested that, unless stage to stage repeatability was higher for Brix than mass, little would have been gained by Brixing the seedlings in this fashion.

Phenotypic Associations

Phenotypic associations for various characters were calculated for the single stool population, and a summary of the more important ones is presented in Table 3.

TABLE 3

A summary of phenotypic associations with mass cane in single stools

	No. of stalks	Thickness	Stalk length	Brix
r =	0,81	0,32	0,49	0,19
Range	0,66–0,87	-0,14–0,56	0,20–0,73	0,03–0,35

It may be seen that for the crosses chosen for this experiment there were not any strong negative associations with mass cane. In particular mass cane was not in any instance negatively associated with Brix; the possibility of such an association being quoted is a cane breeder's nightmare!

The number of stalks per stool was strongly correlated with mass and in this case was better than grade and mass (r = 0,75). Mariotti and Lascano[7] have determined phenotypic associations for many characters and it is interesting to note that the few examined in this experiment appear to agree reasonably closely with their determinations.

Selection in Plant Cane or Ratoon

The mass cane of the plant cane crop was compared with the ratoon harvest in the single stools. Scatter diagrams are given for 3 different crosses in Figure 3. Associations within crosses were about r = 0,65. The diagrams show that for stools of equivalent plant cane mass, there were considerable differences in ratoon cane mass for the crosses b72 and b104. It appears possible that this apparent difference in ratooning ability, between these two crosses, was influenced by a soil × rainfall interaction. This aspect will be more fully studied when the ratoon crop in single lines is harvested.

Genetic Advance in Single Stool Selection

The results detailed above refer to phenotypic achievements of selection and no attempt has been made to determine whether there was any real genetic gain in the selection of the single stools. An immediate difficulty was the measurement of the true genetic value of the seedlings involved. Attention has already been drawn to the high degree of environmental variability in single stools and in single lines these environmental effects are likely to remain high.

A possible way to consider this advance in relative terms, was to compare the mean values of selected and unselected seedlings in respect to their single line performance. In this case the selected and unselected seedlings would be compared in an environment that is almost common to both populations. This comparison is shown in Table 4.

The real improvement of cane mass attributable to selection in the single stools ("the real gain from selection = Δ G; "Skinner[10]) was therefore

$$\Delta G = \frac{152{,}1 - 125{,}0}{125{,}0} \times 100$$
$$= 21{,}6\%$$

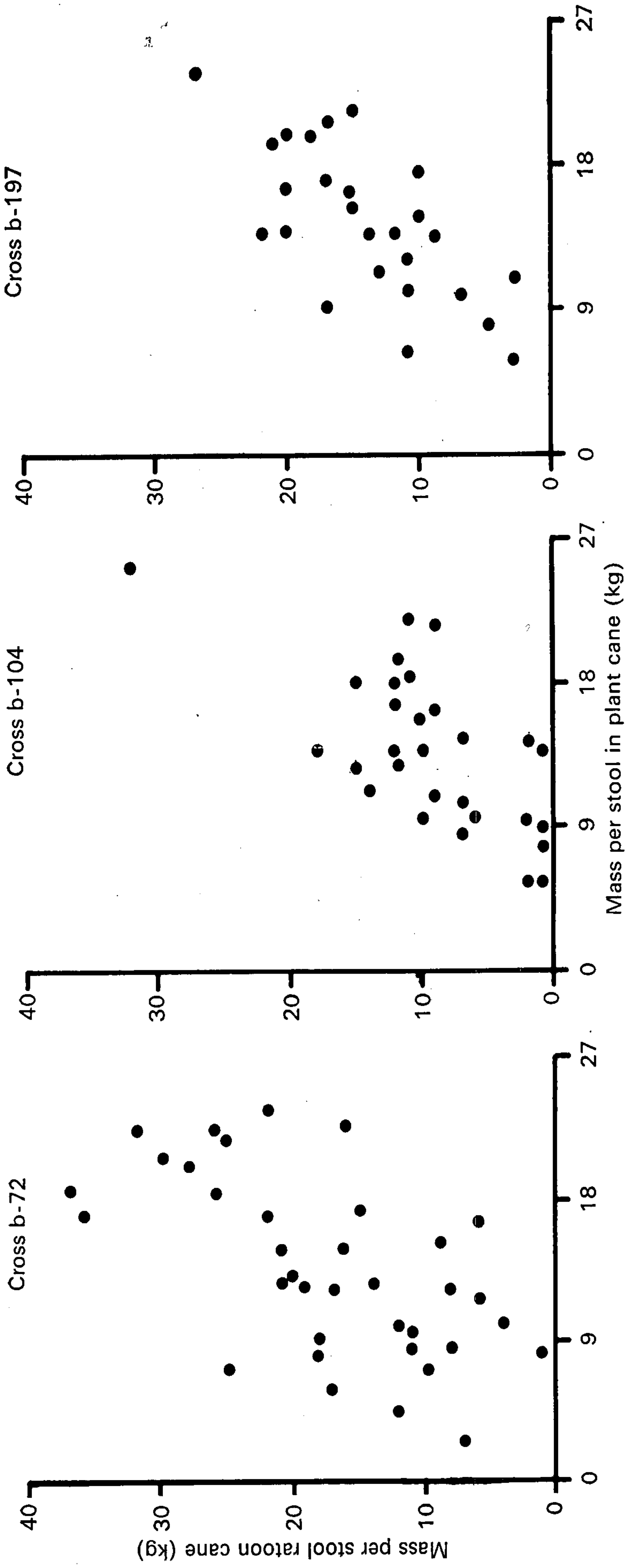

FIGURE 3: Association of mass cane at single stool stage with mass cane at single lines.

TABLE 4

The mean values for mass cane and estimated recoverable sugar, in single lines, derived from selected and unselected stools

	Mass cane	ERS %	Mass ERS
Selected seedlings	152,1	11,1	16,9
Unselected seedlings	125,0	10,9	13,6

This improvement in mass cane was not accompanied by any appreciable change in the value for estimated recoverable sugar.

Skinner[10] points out that the real gain is related to apparent gain or selection differential (D) by the degree of genetic determination (g^2).

$$\Delta G = Dg^2$$

$$g^2 = \frac{\Delta G}{D}$$

In this experiment, for mass cane, the degree of genetic determination was 0,4. This figure compares favourably with other measurements of the degree of genetic determination. Hogarth[5] attributes a figure of 0,21 as single plants. Mariotti[8] gives a figure of 38% for heritability of cane yield, from single stools to the next clonal stage.

Although no selection for sugar content was carried out in this experiment, the theoretical degree of genetic determination may be calculated in the same way.

In the first instance the Brix determinations for the plant cane single stools were used to determine the degree of genetic determination of sugar content.

$$\Delta G = \frac{17,6 - 17,7}{17,7} = -0,056$$

$$D = \frac{16,7 - 14,1}{14,1} = 18,4$$

$$g^2 = -0,003$$

A second determination, using Brix values obtained from the ratoon single stools, also gave a low figure.

$$\Delta G = \frac{18,4 - 17,8}{17,8} = 3,4$$

$$D = \frac{19,4 - 16,5}{16,5} = 17,6$$

$$g^2 = 0,19$$

The degree of genetic determination may also be calculated from the correlation between measurements of the same clones in successive selection stages. These correlations were calculated for various measurements taken in this trial and they are presented in Table 5.

The poor correlation of the Brix values between single stools and single lines is apparent. If, however, the data were broken up into smaller "blocks", to coincide with the different crosses, then some crosses showed a fair correlation, whilst other crosses showed no correlation. (Table 6).

TABLE 5

Correlations between single stools and single lines for various characters

Single stools	Single lines	Correlation	
		Overall	Combined*
Mass (plant)	Mass (plant)	0,36	0,50
Mass (ratoon)	Mass (plant)	0,35	0,46
Brix (plant)	ERS % (June sample)	-0,095	0,26
Brix (plant)	ERS % (Dec. sample)	—	0,28
Brix (ratoon)	ERS % (June sample)	0,15	0,28
Brix (ratoon)	ERS % (Dec. sample)	0,52	0,39

*'Within cross' estimate

The ratoon Brix sample of the single stools, taken in December, 1972, gave a much better correlation with the single line sample, also taken in December, 1972. This might suggest that a variety × season interaction was influencing the result. Table 6 shows how crosses with a high mean Brix value in single stools tend to have low mean ERS values in single lines, leading to a low overall correlation for sugar content.

TABLE 6

Showing the mean Brix in single stools compared with mean ERS in single line according to crosses

Cross No.	Line Nos	Mean Brix in single stools	Mean ERS in S. line (June)	r
b- 72	1108–1126	12,8	11,0	0,23
b- 72	1129–1148	12,4	11,3	0,40
b- 72	1155–1174	12,9	10,6	0,35
b-139	1179–1187	13,7	11,0	0,72
b-139	1200–1216	14,3	11,3	-0,03
b- 58	1221–1240	13,8	11,0	0,42
b- 58	1243–1262	14,1	9,1	0,31
b-223	1319–1338	15,3	10,4	0,14
b-223	1347–1365	14,3	10,0	0,01
b-104	1431–1449	16,0	9,4	0,06
b-104	1452–1469	15,9	8,8	0,33

Other factors, including lodging in the single lines, may have contributed to the poor correlations, and further samples in June and November are planned to try and explain these results.

The association between single stools and single lines as mass cane was also plotted as a scatter diagram (Figure 4). This shows the poor association between the two stages, particularly for the modal values. The selections cover a wide range of cane yields, much of the variability being due to environmental factors rather then genetic. An important point that may be noted from this diagram, is the high frequency of lines without competition at the high levels of single line performance. These seedlings were next to lines which failed to germinate or were extremely poor material.

Conclusions

The elimination of very poor seedlings when planting out to single stools would not seriously affect the selections taken and in addition, by reducing the

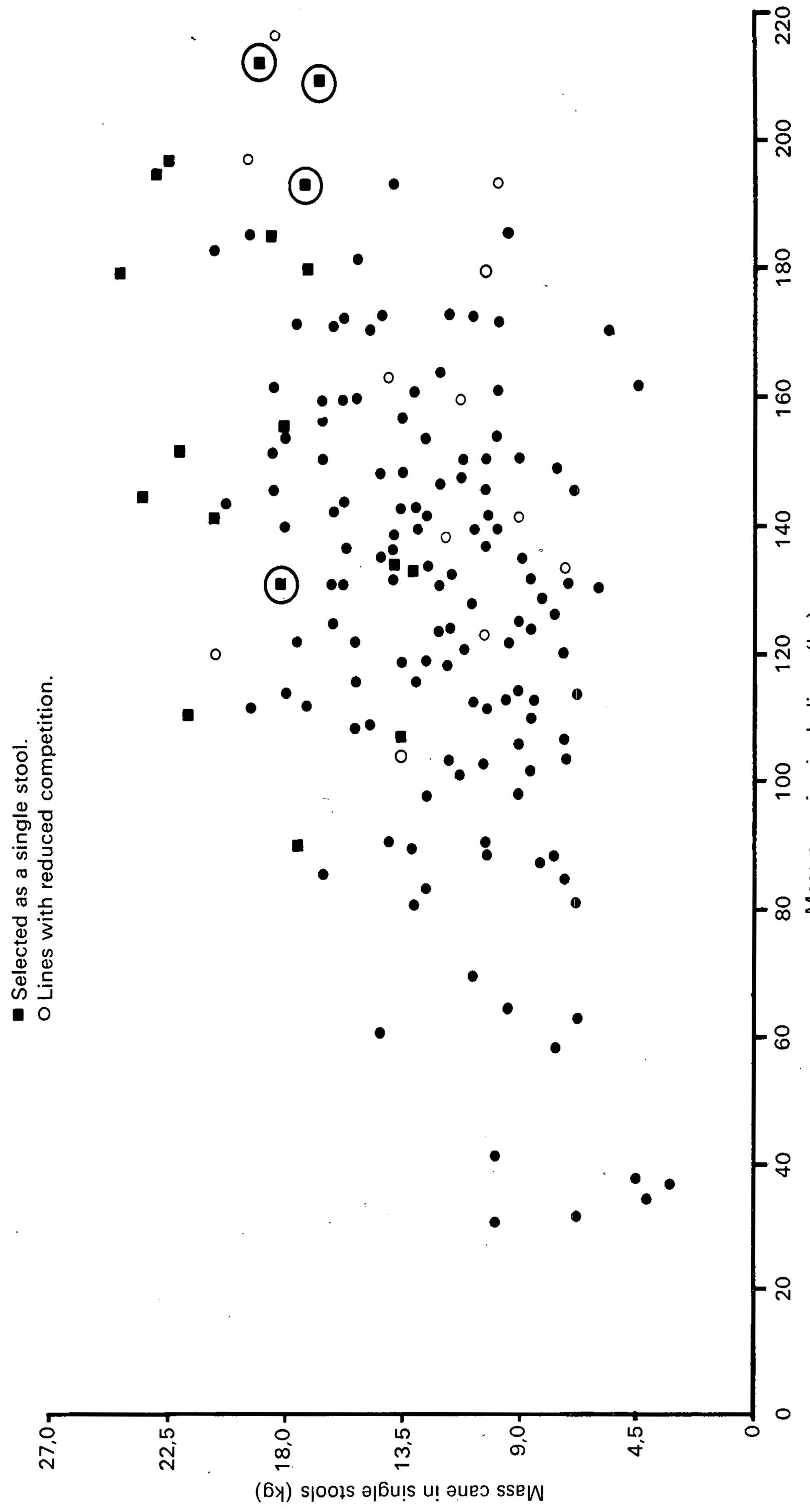

FIGURE 4: The relationship between plant and ratoon crops for different crosses in the single stools.

APPENDIX A

Seedling No.	Single stool data			Selector A	Selector B	Best $7\frac{1}{2}\%$ on Mass	Best 7% on Brix
	Mass	Brix	Mass Brix				
7	21,0	14,5	3,04	*	*	*	
8	17,0	11,5	1,95	*			
17	18,5	15,5	2,87		*		
29	19,0	12,5	2,37	*			
33	15,4	12,0	1,85		*		
35	15,0	15,0	2,25	*			
37	18,0	14,0	2,52		*		
40	20,5	11,0	2,26			*	
44	22,0	14,0	3,08			*	
54	17,0	13,0	2,21	*			
56	18,0	15,0	2,70	*			
63	19,5	14,5	2,83		*		
69	23,0	14,5	3,33	*	*	*	*
79	14,5	14,0	2,03	*			
82	14,0	13,5	1,89		*		
85	13,0	13,5	1,76		*		
87	15,0	15,0	2,25		*		
100	24,5	14,5	3,55	*	*	*	*
103	12,0	14,0	1,68	*			
109	23,0	14,5	3,34	*	*	*	*
138	13,0	14,0	1,82	*			
142	16,5	16,5	2,72		*		
143	14,0	14,5	2,03	*			
151	23,0	14,2	3,27	*	*	*	*
173	19,5	14,3	2,79		*	*	
199	13,0	16,5	2,15		*		
200	17,5	14,2	2,49		*		
221	21,0	15,0	3,15			*	*
224	18,0	17,0	3,06				*
225	20,5	16,5	3,38			*	*
230	24,0	16,2	3,89			*	*
233	25,0	15,0	3,75			*	*
248	22,0	14,2	3,12		*	*	*
252	24,0	13,0	3,12	*	*	*	*
260	20,0	13,0	2,60	*		*	
262	29,5	12,5	3,69	*	*	*	*
264	18,0	11,5	2,07	*			
267	13,5	13,0	1,76	*			
285	20,0	11,0	2,20	*			
288	28,0	12,0	3,36	*		*	*
293	24,0	14,5	3,48			*	*
299	28,0	14,5	4,06	*		*	*
312	21,5	12,0	2,58		*	*	
319	17,5	16,0	2,80		*		
323	18,5	15,5	2,87	*	*		
335	22,0	16,5	3,63		*	*	*
338	18,0	16,5	2,97	*			
340	18,5	16,5	3,05		*		*
341	19,5	18,5	3,61		*		*
343	16,0	16,0	2,56		*		
366	16,5	18,5	3,05				*
No. selected				24	26	21	19
Mean mass cane per stool				19,6	19,4	23,2	22,8

No. of selections in common: 8
Total number of selections by 2 selectors: 43

number of gaps in seedling populations, may appreciably reduce environmental influences in the selection.

Selection may be carried out at a relatively early stage without substantially altering the selection pressure on mass cane. Here it should be mentioned that selector B selecting in May achieved almost the same selection differential as selector A, who was selecting six months later in November.

Selection for mass cane in ratoon cane was no better than in plant cane in so far as the correlation between the single stools and single lines was similar whether plant cane or ratoon cane figures were used.

In this experiment the degree of genetic determination for sugar content was variable, apparently according to the season of sampling. An attempt to combine grading and Brix as a means to selecting did not improve the selection differential in terms of mass Brix, nor was there any difference between these selections and the normal selections in respect to mass estimated recoverable sugar in the single lines. The grade and Brix method averaged 16,6 kg ERS compared with the normal at 16,9 kg ERS. A further factor relating to using Brix as a selection criterion, was that even if selection had been based on Brix alone and the best 10% taken, a selection difference of only 22,7% was obtained compared with 54% in the selection for mass cane. This indicates that in the crosses used in this experiment, Brix had a rather narrow distribution about the means. Work[3] at Bundaberg Station in Australia has indicated a low genetic coefficient of variation (6,5%) for Brix. It would appear that at this early stage of selection, more is likely to be achieved from selecting for mass than Brix.

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