FINAL STAGE TRANSFERS IN A REGIONAL BREEDING AND SELECTION PROGRAMME FOR SUGARCANE

RC PARFITT AND DW THOMAS

South African Sugar Association Experiment Station, Private Bag X02, Mount Edgecombe 4300, South Africa

The aim of sugarcane breeders is the same throughout the world – to develop varieties that provide maximum economic returns under the conditions for which they are intended. New breeding practices that either result in similar gains in less time or input, or more gain per time period, constitute improved practices.

The environment plays a very important role in determining the effectiveness of a clonal selection policy in sugarcane. Where genotype x site interaction is large, breeders face a choice between selecting genotypes with high mean yield across all trial environments (broadly adapted) versus those that perform well in a subset of trials but perhaps poorly in others (specifically adapted). When varieties are selected in one locality only, the effectiveness of the selection is expected to decrease if the genotype x environment interaction is large. The other extreme of planting selections in several locations at a very early stage may also be inefficient because it is much cheaper to evaluate numerous selections at a single location.

The framework for the selection programme that is followed at the South African Sugar Association Experiment Station (SASEX) was laid down by Brett in the early 1950s (Brett, 1952; 1954). In 1965 the growing of the early selection stages including single stools, was decentralised with a view to selecting varieties better adapted to the diverse conditions existing within the South African sugarcane belt. Until the late 1990s selection was carried out at six different sites (Table 1).

Interchange of genetic material among the six programmes of SASEX was carried out at the final selection stage (stage 5). Approximately three top varieties from stage 5 trials of each programme were transferred to stage 5 trials of the other programmes for testing. The purpose of 'transfers' was to identify varieties that also show superiority in other programmes/regions.

The recent commissioning of new farms more representative of the major ecological areas of the industry has placed the plant breeding department in a better position to develop varieties more specifically bred and selected for the different regions. These regions have the characteristics of 'mega-environments' as described by Gauch and Zobel (1997) and have separate breeding and selection programmes.

In Australia, separate sugarcane selection programmes are conducted within six different regions that are separated by latitude. The regional programmes are used as a basis for allocating resources, to rationalise germplasm exchange, to increase heritability in genetic populations being tested and to improve efficiency of selection (Jackson and McRae, 1998).

The new research stations have become fully operational to the point that top varieties in stage 5 trials are available as 'transfers'. In discussing whether 'transfers' should continue as before, the question was asked, 'Are there indications from historical plant breeding trial data that transfers among the different programmes/regions were worthwhile or not'?

Sucrose yield records for all varieties that reached stage 5 in the selection programmes were obtained from the plant breeding variety database. Stage 5 trials consist of approximately 25 varieties with three replications. These trials have been established annually in most programmes since 1981, with each trial being harvested and data collected for three crops. The mean sucrose yield of varieties was calculated for each trial (over crops) for every programme. Trials with data for only one crop were not included in the analysis. Varieties for each trial at each programme were then ranked according to the mean sucrose

Table 1. The six Plant Breeding farms where selection was carried out prior to 1997.

Farm	Code	Conditions represented	Cutting length (months)
Pongola	F	Northern irrigated areas	12
Mtunzini	M	Main coastal belt (Eldana resistance)	15-18
Shakaskraal	W	Main coastal belt (supplementary irrigation)	12-14
Experiment Station	E	Main coastal belt (dryland)	12-14
Central Field Station	L	Main coastal belt (Recent Sands)	15-18
Wartburg	H	Natal midlands (high altitude)	22-24

yield and allocated a code (Table 1) depending on where the variety was originally selected.

Table 2 shows the number of varieties, by code where they were originally selected, and which were tested in stage 5 trials at the different programmes over the 17-year period from 1981 to 1997. Also shown in Table 2 are the numbers of transferred varieties (in parenthesis) represented in the ranked top five of other programmes. This top 20 percent is where future commercial varieties are most likely to be selected. Very few varieties were transferred from the southern programmes (E, H, L, M, and W) to the Pongola (F) programme representing the northern irrigated region. There was also a discrepancy between the number of transfers between the long (L, M and H) and short (E and W) cutting cycle dryland programmes compared with the number transferred within the long and short programmes. This was due to the way in which the programmes were managed, with fewer more strictly selected varieties being transferred between the long (L, M and H) and short (E and W) cutting cycle dry-land programmes.

To identify trends the percentage of varieties in the top five relative to the percentage of varieties tested were calculated for all transfer options and are shown in Table 3. Varieties bred and tested in the same programme (home to home) all had positive values depicting an increased percentage within the top five ranking varieties proportionate to the base, or original, percentage tested. The Pongola (F) to Pongola (F) value is only 1.7%, and can presumably be explained by the high percentage (74.1%) of Pongola varieties tested at home.

Negative values represent a decreased proportion of varieties within the ranked top five relative to the original number tested, i.e. the chances of finding a commercial variety within transfers with negative percentages is lower than that of transfers with positive percentages. The negative percentages for transfers from short cutting-length coastal programmes (E and W) (12 month) to long cutting-length coastal programmes (L and M) (18 month), and visa versa, suggest that cutting length is an important factor to take into account when transferring varieties among programmes. Also interesting are the percentages obtained for transfers between the two short cutting-length coastal programmes (E and W). Varieties transferred from Experiment Station (E) to Shakaskraal (W) performed relatively well, but not varieties transferred from Shakaskraal (W) to Experiment Station (E). Possible reasons for this are that the Experiment Station was a more fertile, uniform site and selection efficiency was higher. The same tendency is noted for transfers between the two long cutting-length coastal programmes (L and M), Central Field Station (L) being the better of the two sites. Chang (1999) found that selection was most effective in the fertile soils of southern Taiwan where phenotypes of plants often reflected their real genotypes and the breeders were capable of making right selections. In contrast, selection efficiency was low in poor environments, e.g. saline and sandy soils, where plant growth was greatly affected by the environment and possibly biased the selection of phenotypes.

Pongola selected varieties seemed to perform well in the Midlands, as was noted by Bond (1994) in a study which looked at the mean yield of variety groups over programmes.

Currently, the safest procedure is the established practice of selecting varieties under conditions approximating as closely as possible those under which they will be grown commercially. As yields increase, it becomes more and more difficult to find stable varieties adapted to a range of sites, and the largest yield increases will come from identifying specific varieties for specific sites (Butterfield, 1995).

There is always a chance that transfers will perform well in other programmes. The data presented, however, indicate that transfers between certain programmes have a better chance of ranking within the top five. Given limited resources and time it is transfers between these programmes that should receive priority.

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Table 2. Number of varieties transferred between stage 5 trials of six programmes in South Africa (1981–1997) together with the number of varieties (in parenthesis) ranked within the top five from each trial on mean sucrose yield.

		To F	E	W	L	M	H
From	**F**	298 (49)	63 (9)	63 (7)	22 (4)	26 (3)	26 (5)
	E	6 (0)	87 (24)	94 (28)	36 (3)	44 (6)	39 (3)
	W	10 (1)	105 (19)	116 (27)	46 (8)	50 (8)	42 (7)
	L	9 (1)	32 (3)	37 (6)	78 (25)	101 (21)	92 (9)
	M	2 (0)	32 (3)	32 (1)	74 (5)	89 (20)	87 (5)
	H	2 (1)	16 (4)	18 (1)	34 (7)	41 (3)	79 (16)
	Total	402 (70)	391 (70)	417 (75)	331 (60)	393 (70)	420 (65)

Table 3. Transfers ranked within the top five expressed as a percentage relative to the original number of transfers tested.

		To F	E	W	L	M	H
	F	1.7	-19.9	-38.4	0.8	-35.0	24.4
	E	-100.0	54.2	65.5	-54.0	-23.2	-50.5
	W	-69.9	0.9	29.4	-4.3	-10.4	8.0
From	**L**	-66.5	-47.5	-9.8	77.0	16.7	-37.0
	M	-100.0	-47.5	-83.1	-62.9	26.3	-62.8
	H	50.8	39.3	-69.9	13.9	-58.8	30.8

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