Tropical Agricultural Research Vol. 9 1997, 26-34

Rank Based Selection Indices for Clonal Evaluation of Sugarcane (*Saccharum spp.*)

A. Wijesuriya, R.O. Thattil[1] and A.L.T. Perera[2]

Postgraduate Institute of Agriculture
University of Peradeniya
Peradeniya, Sri Lanka

ABSTRACT. *Two indices were constructed for initial and intermediate stages of selection based on the data and information derived from an analysis of nine biparental families, their parents and two standard varieties, to be used in the clonal evaluation of sugarcane. The characters; stalk length, hand refractometer brix and rind hardness were chosen for the index proposed for selection at initial stages. Stalk length, purity, laboratory brix and fibre % (fresh weight) were selected to the index suggested for intermediate stages. Ranking of phenotypic values of characters was done for the identification of superiority of the traits. Index coefficients were assigned based on the relative economic importance of the traits. Use of these indices in the selection of proven parents and cross combinations are illustrated in relation to the practical aspects of sugarcane breeding. The best five varieties among the parents were found to be (in order of importance), NCO 339, SL 7785, SL 7771, CO 6415 and SL 8301.*

INTRODUCTION

Use of effective methods in choosing parents for hybridization, selection of proven families or cross combinations and better performing progenies for the advancement along testing stages leading to commercial release is of paramount importance in the varietal improvement of sugarcane. In this regard, construction of selection indices based on the information derived from an appropriate set of families on the inter-relationships amongst characters which determine the cane and sugar yields and direct measurements

---

1 Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

2 Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

of them provide a more efficient way to enhance improvement in multiple traits. This method objectively combines data from various stages of testing or from different relatives within a population.

The index method, although an effective selection method, is not widely used in sugarcane or in other crops, mainly due to additional costs involved in collecting data and is considered to be unjustified in view of the rate of yield improvement gained (Prichard *et al.*, 1973). However, there are several reports where the index selection methodology was effectively applied to sugarcane by Miller *et al.* (1978). An economic sugar index (ESI) has been used for many years in Jamaica in all stages of the varietal selection program (Shaw, 1982). Moreover, recent developments in the application of electronic devices in collecting field data and subsequent analyses have made the use of index selection more practicable. The objective of this study was to develop selection indices for clonal evaluation of sugarcane. This paper introduces two simple rank indices constructed based on the information from a quantitative genetic experiment for the adoption in clonal evaluation at initial and intermediate stages of the selection programme.

MATERIALS AND METHODS

Data and the information collected on genetic and phenotypic parameters from the analysis of a quantitative genetic experiment in sugarcane were used in the development of selection indices. This experiment consisted of nine biparental families selected randomly from the stage I of the 1989 series of sugarcane breeding programme, their parents and two standard varieties. The experimental plots were established in March 1991 at the Sugarcane Research Institute, Uda Walawe in the low country dry zone (DL_1) of Sri Lanka. The details of the experiment; design, plot size and data collection were described by Wijesuriya *et al.* (1993).

The set of data comprised of the following variables.

a) Components of cane yield - stalk diameter (SG), stalk length (SL), clump weight (CW), millable stalks per clump (MS) and tiller count per clump (TC).

b) Components of sugar content - hand refractometer brix (HBRIX), laboratory brix (LBRIX) and pol in juice (POL[1]).

c) Components of fibre content - rind hardness (RD) and fibre % (fresh weight) (FIB).

d) Derived variables - purity (PUR) = [(pol/brix[2]) × 100] and pure obtainable cane sugar (POCS[3]).

Traits for the indices were selected based on broad-sense heritabilities, genetic and phenotypic correlations, direct and correlated responses to selection estimated by Wijesuriya *et al.* (1993) and on the relative economic importance of traits.

At the initial stages of selection, direct selection for cane yield, sugar content and fibre % (fresh weight) is difficult as it involves tedious laboratory procedures. Therefore, easily measurable characters with high heritability, high correlations at phenotypic and genotypic levels and higher expected direct and correlated responses to selection were used as traits for the index. As such, stalk length, hand refractometer brix and rind hardness were chosen as the representatives of target traits for cane yield, sugar content and fibre % (fresh weight), respectively.

Data on several variables of sugar and fibre analyses are available at intermediate stages of selection. Therefore, the characters; purity and laboratory brix were chosen for the index to describe the sugar yield since they are highly heritable and correlated with POCS. Moreover, POCS has the advantage of being selected through purity as it has higher correlated response than direct response to selection. Laboratory brix was selected omitting pol% for the index due to the measurement artifact of calculating purity through the equation; purity = pol/brix. Therefore, the clones with high purity have higher pol% or lower brix in juice. Varieties with low brix are not accepted by sugarcane breeders. Thus, brix is selected to the index instead of pol%. Stalk

---

1 A measure of % sucrose in juice.

2 A measure of % soluble solids in juice.

3 POCS = % sugar in cane - (1/2 × % impurities in cane)
% impurities in cane = % soluble solids in cane - % sugar in cane.

length was selected to the index for the representation of cane yield due to the similar reasons described for the selection of purity (Wijesuriya *et al.*, 1993). The character FIB was chosen for the index to represent fibre.

The proposed selection indices involve ranking of phenotypic values of each character from highest to lowest except for FIB and RD. For these two traits, ranking was done on the absolute deviations from the optimum fibre level required by the sugar factories. Most factories operate at the maximum efficiency when canes with 13% fibre are crushed. This value was taken as the optimum value for fibre and the corresponding optimum value for rind hardness was determined through the relationship between FIB and RD.

Allocation of index coefficients for the traits in the indices was done on the basis of relative economic importance of characters determined by sugarcane breeders. As the prime intention is to develop varieties with high cane yield, high sugar yield and optimum fibre content, it is observable that all three categories of variables are of equal importance. However in this study, the following facts are taken into consideration in the determination of index coefficients for the characters.

a) Quality based cane payment system; higher prices are offered by most sugar factories for the supply of canes with high POCS as it is the ultimate decisive factor for higher recovery of sugar.

b) The characters that determine sugar content in cane are more repeatable, highly heritable with less variability in the populations when compared to morphological and quality traits.

The indices constructed for initial and intermediate stages of selection were as follows;

Index for selection at initial stages:

I_{INIT} = 0.3 (rank of stalk length) + 0.4 (rank of hand refractometer brix) + 0.3 (rank of rind hardness)

Index for selection at intermediate stages:

I_{INTER} = 0.3 (rank of stalk length) + 0.2 (rank of purity) + 0.2 (rank of laboratory brix) + 0.3 (rank of fibre% [fresh weight])

The constructed indices are of the form $I = \sum a_i R_i$ where, a_i is the economic weight and R_i is the rank given for the i^{th} trait to identify phenotypic superiority. The selection of clones were done on their calculated index values, in contrast to the index value of the commercial standard Co 775.

RESULTS AND DISCUSSION

In this study, the required genetic and phenotypic parameters were estimated using a simple method that involve giving weights to the ranks depending on the respective economic values of the characters for the clonal selection of sugarcane. The index is similar to the Williams (1962) index in most of the aspects except in the way of identification of phenotypic superiority of characters. Williams (1962) assigned the weights to the phenotypic values of characters whereas, the index suggested here involve weighing of ranks of the characters. The phenotypic merit of a character of an individual in a population can be identified easily in the form of ranks and this would be an added advantage for the breeder during selection.

The index constructed for the intermediate stages of selection was employed for the identification of proven parents in this study. The ranks given for each character and the index values calculated and their ranks for the parent varieties are presented in Table 1. The results show that the parent variety NCo 339 performed well over the other varieties tested. The best five varieties among the parents in the order of importance were, NCo 339, SL 7785, SL 7771, Co 6415 and SL 8301. The commercial standard, Co 775 was ranked as 8^{th} indicating that most varieties selected as parents are with good commercial attributes for use in hybridization programmes. The varieties, Co 997 and Co 1148 can also be included in the list of proven parents since they were ranked above the commercial standard. Exploitation of individual traits included or excluded in the index can be done using the ranks obtained by a parent for each character.

Indices constructed for initial and intermediate stages were used to identify proven crosses out of the nine biparental cross combinations evaluated in the study. Ranking of families on the average of the index values of the progenies within families and number of individuals selected at selection intensities 10% and 20% for both indices show that the first five cross combinations detected through the indices consist of four common families. Family 7 was found among the first five according to the index for initial stages but ranked 6^{th} in the other index. Similarly, family 1 ranked 6^{th} by the index

Table 1. Performance of Parents on the Selection Index Proposed for Intermediate Stages.

Parents	SL*	SG	MS	CW	TC	HBRIX	LBRIX	POL	PUR	POCS	FIB	RD	SD of ranks	I_{smra}	Rank
SL8303	7	9	13	11	11	14	14	14	12	13	7	2	3.55	9.4	14
POJ2875	8	2	10	8	8	13	13	13	13	12	6	1	4.07	9.4	14
SL7225	4	1	11	5	14	11	12	11	10	11	9	12	3.70	8.3	11
SL7771	1	11	3	2	4	7	7	7	7	8	10	9	3.04	6.1	3
SL8301	13	7	12	13	5	5	11	8	2	4	2	10	3.92	7.1	5
SL7785	3	4	7	3	9	6	8	3	3	2	8	6	2.34	5.5	2
Co6415	2	3	1	1	13	1	2	5	8	7	13	14	4.86	6.5	4
CP71321	12	12	6	12	3	9	5	9	11	9	5	7	2.98	8.3	11
Co997	6	10	9	7	10	3	3	2	4	6	14	13	3.81	7.4	6
Co1148	11	13	2	10	1	12	10	10	9	10	3	3	4.10	8.0	7
SL7130	9	6	5	6	6	8	6	4	5	3	11	5	2.11	8.2	10
NCo339	10	14	4	9	2	2	1	1	1	1	4	4	4.11	4.6	1
Co775	5	8	8	4	12	4	9	6	6	5	12	8	2.65	8.1	8
CP63306	14	5	14	14	7	10	4	12	14	14	1	11	4.43	8.1	8

* Ranks - Lower values are favourable
SL = Stalk length, SG = Stalk diameter, MS = Millable stalks per clump, TC = Tillers per clump, HBRIX = Hand refractometer brix, LBRIX = Laboratory brix, POL = Pol % in juice, PUR = Purity %, POCS = Pure Obtainable Cane Sugar, FIB = Fibre % fresh weight, RD = Rind hardness

for initial stages was included within the first five families according to the index proposed for intermediate stages. As expected more number of progenies were selected from the groups of the first five families, by both indices. Therefore, the following cross combinations were selected as proven crosses to be used in the future crossing programmes.

Proven Cross Combination			Family Number
NCo 339	x	SL7771	8
CP71321	x	Co6415	5
SL7225	x	SL7771	2
SL7785	x	Co6415	4
NCo339	x	Co775	7
SL8301	x	POJ2875	1

The involvement of proven parents detected by the previous section were high in the proven crosses and hence one can expect better families with promising individuals by incorporating proven parents in biparental and poly crosses of sugarcane.

Since, clonally replicated individual clumps from seedlings were used as the experimental unit, clonal selection at seedling populations can be simulated using the data obtained from the experiment. Moreover, all the test clumps were assessed for the components of sugar and cane yields and FIB. Therefore, it was possible to apply the index selection methodology according to the selection criteria used at intermediate stages of selection using the data collected from the experiment.

The mean phenotypic values of 450 individuals from 9 families were ranked per character basis in the calculation of index values for every individual. The best 10% of the progenies (*i.e.* 45 progenies) were then selected on the index values. Similar procedure was employed in using the indices constructed for initial and intermediate stages of selection.

Progenies in the population were assessed more accurately for the target traits by the index proposed for intermediate stages. Therefore, it is important to observe how many progenies selected at the intermediate stages have repeatedly been selected by the index for initial stages. The proportion of selected clones by the index for initial stages is needed to decide the appropriate rate of selection at the initial stages.

The results show that only 16 progenies were selected when 10% of the population (*i.e.*45 progenies) is selected by the index for initial stages. When 20% of the original population was selected, 27 progenies were classified properly. Therefore, it is apparent that when selection is less stringent at initial stages it ensures the advancement of better clones for later stages. This is

applicable for the practical situation in clonal selection of sugarcane. However, when selection is progressing in the field, attributes such as disease reaction, lodging, erectness, stalk diameter and several other characters are taken into consideration for further elimination of varieties.

Stalk length was included in both indices representing cane yield. Gravois *et al.* (1991) highlighted that when selection for cane yield cannot be accomplished directly, then selection for stalk weight can be used. Stalk weight can be effectively increased by visual selection for stalks with large volumes which can be accomplished by emphasizing stalk diameter and stalk height. Therefore, in the practical use of the selection index at initial stages, only the clones with acceptable stalk diameters should be considered for index selection. Similarly, the work involved in index selection can be reduced by the visual elimination of varieties without acceptable phenotypic values before recording the measurements for index calculation.

The selection indices proposed in this study provide an effective method for selection of parents, planning parental combinations and selection of progenies from the various testing stages of sugarcane. Breeding and selection of sugarcane generally require all the back-ground knowledge, training and intuition that the breeder can master with experience.

CONCLUSIONS

Use of ranks instead of actual phenotypic values of characters provides an easy way of identifying phenotypic merit of an individual in comparison to other members in a large population. For the initial stages, selection on the characters; hand refractometer brix, stalk length and rind hardness was identified as most suitable selection criteria. Selection for higher purity, laboratory brix, stalk length and moderate fibre % (fresh weight) were found to be appropriate for the intermediate stages. Clonal selection using indices suggested that a higher percentage of selection have to be used at initial stages to avoid elimination of better lines at later stages.

The best five varieties among the parents in the order of importance were; NCo 339, SL 7785, SL 7771, Co 6415 and SL 8301. The involvement of these proven parents in proven crosses highlighted that one can expect better families with promising individuals by incorporating proven parents in cross combinations of sugarcane.

REFERENCES

Gravois, K.A., Milligan, S.B. and Martin, F.A. (1991). Indirect selection for increased sucrose yield in early sugarcane testing stages. Field Crops Research. 26: 66-72.

Miller, J.D., James, N.I. and Lyrene, P.M. (1978). Selection indices in sugarcane. Crop Sci. 18: 369-372.

Pritchard, A.J., Byth, D.C. and Bray, R.A. (1973). Genetic variability and the application of selection indices for yield improvement in two soya bean populations. Aust. J. Agric. Res. 24: 81-89.

Shaw, M.E.A. (1982). Aspects of variety improvement. Proc. Inter-Am. Sugarcane Seminar. 3: 106-114.

Williams, J.S. (1962). The evaluation of a selection index. Biometrics. 18: 375-392.

Wijesuriya, A., Thattil, R.O. and Perera, A.L.T. (1993). Selection criteria used in clonal evaluation of sugarcane (*Saccharum spp.*). Trop. Agric. Res. 5:109-119.