

## **PARENT SELECTION FOR DIRECTIONAL BREEDING OF SUGARCANE (*SACCHARUM HYBRID SPP.*)**

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### **Abstract**

Parental worth of 217 sugarcane accessions was appraised in this experiment to identify parents to be used in crosses directed to high cane yield, high sugar content in juice and moderate fiber content. The appraisal comprised estimation of breeding values of accessions for yield components, clustering of accessions for making core-collections and estimation of association between yield components of sugarcane. The accessions were tested for cane and sugar yield components in plant crop and in ratoon 1 crop. Analysis of variance, cluster analysis and breeding values of accessions were used to select the parents. Association between characteristics was found through phenotypic correlations.

Significant differences of yield components showed among the accessions indicated that there is a good potential for selection of parent clones for directional breeding of sugarcane. The correlation studies proved that stalk length and number of stalks are the major determinants of cane yield. Cluster analysis and estimation of breeding values of parents were proved to be the useful tools in selection of parents for directional breeding. Nineteen accessions were found as parents for crosses to improve both cane yield and sugar content, simultaneously. Nearly 10 percent of the accessions in the population were classified as the parents in crosses to be performed for directional breeding of respective characteristics using breeding values. The accessions Co 775 and PH 58260 were identified as parents for incorporation of moderate fiber content in high sugar progenies.

*Keywords:* breeding values, directional breeding, parent selection, sugarcane

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## Introduction

Sugarcane (*Saccharum* hybrid spp.) is cultivated globally as a main source of raw material for production of sugar. Currently, Sri Lanka produces about 6 percent of the local sugar requirement, which is around 650,000 tons per annum. The present government has set targets and launched programmes as per the Mahinda Chinthana Development Framework (Anon., 2005) to achieve 40 percent self-sufficiency in sugar by year 2020 and 100 percent by year 2030. Sugarcane variety improvement plays a major role in achieving the said targets by developing new varieties with commercial attributes and in selection of varieties suitable for growing in different agro-ecological regions in the country.

The crop improvement programme conducted by the Sugarcane Research Institute comprised projects on plant introduction, local collection, breeding, production of calli clones through tissue culture and modern biotechnology. Selection pressure is applied on the genetically variable sugarcane populations created by these projects to select varieties with higher cane yields and sugar contents, equitable fiber and resistance to major pests and diseases. The basic genetic material for sugarcane crop improvement is supplied by the plant species in the “*Saccharum* complex” that be composed of genera *Saccharum*, *Erianthus*, *Miscanthus*, *Sclerostachya* and *Narenga* (Roach and Daniels., 1987). Germplasm evaluation, parental selection in hybridization and progeny selection using appropriate methodologies increase the efficiency of the sugarcane breeding programme. The present study was carried out to assess the parental worth of 217 sugarcane accessions to identify the most suitable parent clones and inclusion of them into the proven parents system for crossings directed to high cane yield, high sugar content in juice and moderate fiber content. The specific objectives of this study were to estimate breeding values of accessions for yield components, clustering of accessions for making core-collections and estimation of association between yield components of sugarcane.

## Methodology

The experiment was laid out in a completely randomized design with two replicates. A uniformly prepared land with furrows opened 1.37 m apart were divided into 1 m plots across the furrow direction and 1 m space was given between two plots. A total of 217 accessions that comprised local collections (131), imported varieties (75) and standard varieties (11) were tested in this experiment in plant crop and ratoon 1 crop. Most of the local collections belong to *Saccharum officinarum* and there were a few hybrids which could not be recognized visually. The imported varieties and standard varieties were hybrid derivatives of early nobilisation work.

Data collected from the plant crop included plot weight (WT), stalk length (SL), stalk diameter (DM), number of stalks (ST) and, hand refractometer brix (HB). In addition to these variables, laboratory brix (BRIX), pol in juice (POL), purity (PUR), pure obtainable cane sugar (POCS) and fiber percentage (FIB) were recorded from the ratoon 1 crop. Analyses of variance for all the characteristics were followed by separation of means employing the Dunnett's procedure against the commercial standard variety Co 775. The association between characteristics was estimated by the phenotypic correlation.

Cluster analysis using agglomerative hierarchical approach was performed for the variables WT and HB for plant crop and WT and POCS ratoon 1 crop to characterize the accessions into more delineated groups separately for cane yield and sugar content. Breeding values of the accessions were estimated as proposed by Marshall (2008) for all characteristics except FIB. The narrow-sense heritability values of the characteristics estimated by Wijesuriya (2012) were used for the estimation of breeding values of the accessions.

## **Results and discussion**

There were significant differences between accessions for all the variables except for stalk length in both plant and ratoon 1 crops. For characteristics which determine cane and sugar yields, a considerable number of the accessions tested had exceeded the value of the standard variety signifying the existence of accessions in the collection, which possess commercial potentials. These accessions were included into the respective core-collections on the basis of superiority in particular characteristic/s.

The matrices of phenotypic correlation coefficients among the characteristics studied in plant crop and ratoon 1 crop are presented in Table 1 and Table 2. The phenotypic relationships observed between WT and SL and WT and ST in plant crop and ratoon 1 crop proposed that SL and ST as the major determinants of cane yield of a sugarcane variety. Among the cane yield components, SD showed non-significant relationship with WT. However, SD has a significant negative relationship with ST. It implies that thicker-caned-clones produce less number of stalks. As such, during parental selection, the accessions with higher number of millable stalks with acceptable diameter have to be selected for directional breeding for cane yield. The relationship between FIB and WT suggests that fibre content in cane contributes to cane yield to some extent. In this study, sugar content in cane is approximated by the variable POCS and therefore POCS is strongly related to sugar yield. The phenotypic correlations between POCS and other biochemical characteristics were positive and very high in magnitude. Fiber contributed to POCS less than the other variables and it has no significant relationship.

**Table 1:** The coefficient of phenotypic correlations among the cane yield and sugar yield components in plant crop.

	SL	ST	DM	HB
WT	0.35***	0.73***	-0.03 <sup>NS</sup>	0.16**
SL		0.39***	-0.19***	0.06 <sup>NS</sup>
ST			-0.13**	0.17***
DM				0.10*

\* significant at  $P \leq 0.05$ , \*\*significant at  $P \leq 0.05$ , \*\*\*significant at  $P \leq 0.001$   
<sup>NS</sup> not significant

**Table 2:** The coefficient of phenotypic correlations among the cane yield and sugar yield components in ratoon 1 crop.

	S L	ST	DM	HB	BRIX	POL	PUR	POCS	FIB
WT	0.24**	0.83***	0.09 <sup>NS</sup>	0.15**	0.22***	0.26***	0.19**	0.23***	0.38***
SL		0.20**	-0.01 <sup>NS</sup>	-0.09 <sup>NS</sup>	-0.01 <sup>NS</sup>	-0.04 <sup>NS</sup>	-0.05 <sup>NS</sup>	-0.05 <sup>NS</sup>	0.18**
ST			-0.16**	0.09 <sup>NS</sup>	0.19**	0.23***	0.08 <sup>NS</sup>	0.19**	0.38***
DM				0.03 <sup>NS</sup>	-0.93 <sup>NS</sup>	-0.05 <sup>NS</sup>	-0.00 <sup>NS</sup>	-0.02 <sup>NS</sup>	-0.23***
HB					0.81***	0.79***	0.58***	0.74***	0.09 <sup>NS</sup>
BRIX						0.91***	0.59***	0.84***	0.09 <sup>NS</sup>
POL							0.59***	0.97***	0.11 <sup>NS</sup>
PUR								0.55***	0.11 <sup>NS</sup>
POCS									0.03 <sup>NS</sup>

\*\* significant at  $P \leq 0.05$ , \*\*\* significant at  $P \leq 0.001$ , <sup>NS</sup> not significant

The relationship observed between HB and BRIX suggests that HB can be successfully used as a measure of brix in sugarcane instead of laboratory brix in the initial stages of clonal selection. The relationships of stalk length to most of biochemical characteristics were non-significant. All these results revealed, cane yield and sugar content are independent complex characteristics which can be improved simultaneously by manipulating their components during clonal selection. Stalk diameter had moderate-negative and significant relationships with fiber percentage. This suggests high fiber content is associated with thinner canes in the populations. Thicker canes consist of more *S. officinarum* (noble) genes and this would probably be the reason for higher sugar in thicker canes. It is a general belief that high fibre is associated with low sugar content and *vice versa*. However, these results indicated that though there is a little tendency of getting low sugar during the selection of clones on high fibre, there are good chances of improving sugar content while keeping the optimum fibre content (13% - 14%) needed for sugar factories.

The clusters appearing in the dendrograms were classified into major groups based on dissimilarity level, 0.9 for grouping of accessions in all 4 cluster analyses. In the cluster analyses on WT and HB in plant crop and WT and POCS in ratoon 1 crop, the accessions were classified into 3 main groups. The number of accessions and the means of each group are presented in Table 3.

**Table 3:** Number of accessions and the means of plot weight, hand refractometer brix, POCS in cluster groups of accessions in plant crop and ratoon 1 crop.

	Plant crop				Ratoon 1 crop			
	WT (kg/plot)		HB		WT (kg/plot)		POCS	
	No. of acc.	Mean	No. of acc.	Mean	No. of acc.	Mean	No. of acc.	Mean
Group 1	164	38.5	103	16.2	133	22.64	98	10.22
Group 2	30	13.6	8	11.9	8	63.95	24	12.24
Group 3	19	78.3	102	19.2	22	42.21	21	6.96

Identification of parents for directional breeding of cane yield and sugar content was done on the basis of means of the cluster groups. Accessions in high mean-WT group and high mean-HB or -POCS group were selected as parents for directional breeding of cane yield and sugar content, respectively. Accordingly, the accessions in group 3 in plant crop and group 2 in ratoon crop 1 were selected. There are 164 accessions in the group 1 categorised on plot weight in plant crop. The commercial standard Co 775 was classified under this group. Therefore, all the accessions in this group can be considered as parents for making inter-varietal crosses. However, this cluster comprised moderate cane-yielding accessions with the average of 38.5 kg per plot. Group 3 in plant crop includes highest cane-yielding accessions with the average of 78.3 kg per plot and there are 19 accessions. Group 2 of plant crop consists of 30 accessions that produced lowest cane yields (average 13.6 kg per plot) among the accessions tested. As such, intra-group crosses i.e. inter-accession crosses within group 3 can be considered as directional crosses for high cane yield. Inter-group crosses between the accessions in group 1 and group 3 can also be proposed with some direction to high cane yield. Crosses within group 2 will produce inferior progenies with regard to cane yield.

Group 1 classified on hand refractometer brix in plant crop consists of 103 accessions with moderate hand refractometer brix values (average-16.2), group 2 with 8 accessions of lowest values (average-11.9) and group 3 with 102 accessions with highest (average-19.2) hand refractometer brix values. Therefore, inter-accession crosses within group 3 are proposed as crosses directed to high sugar contents. There are 14 common accessions (Table 4) in group 3 in plant crop classified both on plot weight and hand refractometer brix and hence they can be considered as parents for crosses producing high cane yielding progenies with high sugar content, simultaneously. The crosses among these varieties are classified as crosses directed to both cane yield and sugar content.

**Table 4:** Accessions identified as parents to be used in directional crosses for simultaneous improvement of cane yield and sugar content (based on plant crop performances).

No.	Accessions	No.	Accessions
1	CP 4333	8	SLC 8 125
2	PH 1164	9	SLC 8 138
3	PH 5333	10	SLC 8 29
4	PH 82193	11	SLC 8 33
5	SL 92 4918	12	SLC 8 57
6	SL 92 4918	13	SLC 8 76
7	SLC 8 110	14	SLC 8 9

Group 2 in ratoon 1 crop (Table 3) includes highest cane-yielding accessions with the average of 63.95 kg per plot and there are 8 accessions in this group. Group 3 of the same crop consists of 22 accessions that produced moderate cane yields (average 42.21 kg per plot) among the accessions tested. As such, intra-group crosses i.e. inter-accession crosses within group 2 of ratoon 1 crop can be considered as directional crosses for high cane yield. Inter-group crosses between the accessions in group 2 and group 3 of ratoon 1 crop can also be proposed with some direction to high cane yield. The crosses within group 1 have been classified as inferior crosses with regard to cane yield. In ratoon 1 crop, group 1 consists of 98 accessions with moderate POCS values (average-10.22), group 2 with 24 accessions of highest values (average-12.24) and group 3 with 21 accessions with lowest (average-6.96) POCS values. Therefore, inter-accession crosses within group 2 are proposed as crosses directed to high sugar contents. The accessions common for group 2 of plot weight and POCS in ratoon 1 crop were chosen for finding parents for directional crosses for simultaneous improvement of cane yield and sugar content and they were listed in Table 5.

**Table 5:** Accessions identified as parents to be used in directional crosses for simultaneous improvement of cane yield and sugar content (based on ratoon 1 crop performances).

No.	Accessions
1	SLC 8 138
2	SLC 8 73
3	SLC 8 126
4	SLC 8 25
5	PH 58260
6	M 33758

The accessions with the best 20 breeding values for all the characteristics i.e. nearly 10 percent of the population were selected as the parents in crosses to be performed for directional breeding of the respective characteristics bearing fibre percentage. The best parents for directional breeding of moderate fiber content were selected considering the BV of the standard variety Co 775. The accessions with closest 7 BVs, each of upper and lower direction to BV of Co 775 were selected as best parents for directional breeding of moderate fibre content. One common parent, characterized by BVs of plot weight and POCS, namely; SLC 8 25, was considered as the parent to be used for simultaneous improvement of cane yield and sugar content. The accessions Co 775 and PH 58260 were classified commonly based on BVs for both POCS and fiber content. As such, these two parents can be considered for incorporation of moderate fiber content in high sugar progenies.

### Conclusion

Significant differences among accessions indicated that there is a good potential for selection of parental clones for directional breeding of sugarcane. The correlation studies proved that stalk length and number of stalks are the major determinants of cane yield of a sugarcane variety. In parental selection, the accessions with higher number of millable stalks with acceptable diameter have to be selected for directional breeding of cane yield. Parents for intra- and inter-group crosses were identified in the clusters for directional breeding of high cane yield and high sugar content. Nineteen accessions were found to be used as parents for crosses directed to improve both cane yield and sugar content simultaneously. Nearly 10 percent of the accessions in the population were classified as the parents in crosses to be performed for directional breeding of the respective characteristics using breeding values. The accessions Co 775 and PH 58260 were chosen as parents for incorporation of moderate fiber content in high sugar progenies.

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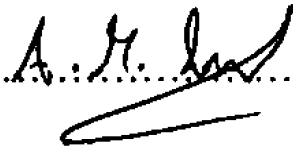
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