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Assessment of the first cycle hybrid progenies for early high sugar content in sugarcane

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Abstract

Enhancing the sucrose content of the varieties through breeding is essential for attaining sustainable sugar production. To achieve this, new parental clones capable of much higher levels of sucrose accumulation than found in the commercial varieties are to be developed. A recurrent selection scheme with a base population of eighteen Indian commercial hybrids and eight exotic hybrids was adopted. Preliminary screening of 5420 hybrid seedling progenies from thirty biparental crosses for juice brix in the ground nursery revealed four productive cross combinations *viz.*, CoC 671 x Co 99002, Co 86002 x Co 7915, Co 7201 x Co 62198 and PR 1080 x Co 94008. These crosses contributed more individuals with high juice brix performing better than the cross average. In the subsequent clonal evaluation of cycle I hybrid progenies, 104 clones registered more than 23 percent juice brix at ten months of crop age. With regard to the progress made in cycle I for juice sucrose, five clones *viz.*, 02-071, 02-094, 02-137, 02-230 and 02-295 recorded more than ten percent improvement over the best check variety CoC 671. Screening the high quality clones for their reaction to red rot pathogen indicated three crosses *viz.*, Co 7201x Co 62198, Co 85002 x CoT 8201 and CP 49-50 x CoT 8201 giving more clones combining high sucrose and red rot resistance.

Key words: Sugarcane, recurrent selection, first selection cycle, clonal evaluation, high sucrose

Introduction

Indian sugar industry has sustained sugar productivity through increased cane yield per unit area, development and cultivation of improved cultivars, good management practices coupled with the adoption of sound disease and pest management strategies. Successful efforts to improve sucrose content through the adoption of different selection strategies coupled with the choice of appropriate parents have been reported in other countries [1, 2]. Earlier selection also has been reported to contribute successfully to the improvement of sucrose content early in the season [3]. When selection is done later in the season, environmental and competition effects mask the true genetic potential of the genotype [4]. In Mauritius, following studies on earliness [5], the selection program was amended to integrate earlier selection. In India, the red rot disease caused by *Colletotrichum falcatum* is a serious disease in different states and continues to be a threat in subtropical regions. The use of resistant varieties is the most effective method of prevention and control. Many high sucrose varieties such as Co 312, Co 997, Co 1148, Co 6304, CoC 671, CoC 8001, CoC 85061, CoC 86062, CoC 90063, CoC 92061 etc. have been eliminated because of their susceptibility to red rot. Biparental crossing has been generally adopted for development of clones with disease resistance. An attempt was made in the present study to identify clones combining high sucrose and resistance to red rot which can serve as a source population for future breeding programmes. The results presented in this paper come from a study conducted to explore the potential of enhancing the sucrose content of sugarcane hybrids through recurring cycles of intermating and selection.

Materials and methods

The experimental material for this study comprised of twentyfive Indian commercial hybrids (Co canes) and twelve exotic hybrids with juice sucrose of $\geq$ 19.0 % at 12 months of crop age. Starting from a base population of 26 high sucrose clones, a simple recurrent selection scheme was adopted. Based on synchrony among the

flowering types, thirty biparental crosses were attempted involving eighteen Indian Co canes and eight exotic hybrids. 5420 seedling progenies were planted with ten seedlings / row of 6 metre length and rows 0.9 metre apart. Screening the hybrid progenies for H.R. brix was taken up at very early stages of sugar accumulation i.e. at ten months after transplanting.

1890 hybrid progenies recording $\geq$ 21.0% H.R. brix were selected from ground nursery and planted in a stage I selection trial i.e. first clonal trial (five clones / row) in an augmented design along with three early standards *viz.*, Co 85004, CoC 671 and Co 2000-03. To identify clones capable of building up of sucrose levels at an early stage, spindle brix was estimated at 240 days of crop age in three cane samples from each progeny.

472 clones performing better than the check variety for juice sucrose *viz.*, CoC 671 were selected and planted in Final clonal trial in an augmented design along with four early standards *viz.*, Co 85004, Co 2000-03, CoC 671 and CoC 90063. Each clone was planted in a single row of 6 metre length spaced at 0.9 meter between rows. Juice quality characters were determined at the tenth month of crop duration. Five whole cane stalks were sampled from each clone for juice analysis. The following juice parameters were estimated *viz.*, a) Pol per cent juice (apparent sucrose of the juice determined by polarization), b) brix (total dissolved solids in juice) and c) commercial cane sugar per cent juice.

To identify clones combining high sugar and red rot resistance, forty six clones from stage II trial were tested for their reaction by CCT method using tropical isolates (CoC 671 and CoC 90063) [7]. Top one half of the cane samples (non-flowering canes of 7-8 months age) are vertically arranged in a humidity chamber maintained at 30°C and freely removable leaves with sheath are peeled away. Pathogen suspension is applied on the top exposed nodes and cotton swabs dipped in the spore suspension are wound around the inoculated nodes. After 7-10 days, the inoculated nodes are scraped and stalk split open, examined and the disease reaction scored.

Results and discussion

The main objective of the present study was to generate a group of clones that had brix and sucrose levels above the upper range of existing commercial clones. Selection right from ground nursery was made rigidly for brix alone, ignoring all other characteristics. The lack of improvement of sugar content in mature, main season varieties can be attributed to relatively low genetic variability for the character in the population compared to the variability for yield [8]. The results presented in this paper pertain to the data on the performance of the first selection cycle progenies with regard to juice brix in ground nursery, stage I selection and stage II selection trials, respectively.

Distribution of juice brix in the population of first generation hybrid progenies

Preliminary screening of 5420 seedling progenies generated from thirty biparental crosses for H.R. brix was taken up at very early stages of sugar accumulation i.e. at ten months of crop age. Comparison of mean brix of progenies derived from different combinations indicated that in the crosses *viz.*, Co 86002 x Co 7915, Co 86010 x CoT 8201, CoC 671 x Co 99002, PR 1080 x Co 94008, more than thirty percent of the progenies recorded $\geq$ 21.0% (Table 1). Hsu *et al.* [9] in a seedling population derived from 63 biparental crosses with parents differing in their sucrose content have reported that the h^2 of brix estimated from the regression of the offspring on the midparent was 0.59 during the month of October. Selection for high brix is, therefore, effective in early stages. The cross CoC 671 x Co 99002 recorded the highest mean brix value of 21.99% followed by another cross Co 7201 x Co 62198 with 20.74%. Earlier studies on systems of selection by Ramana Rao *et al.* [10] at the Sugarcane Breeding Institute identified the following families *viz.*, CoC 671 x MS 68/47, Q 68 x MS 68/47 and Co 7704 x MS 68/47 for the realisation of high quality clones. New selection techniques, such as family selection, have been adopted in Barbados variety selection programme to give more emphasis in the search for high quality varieties [11]. Among the crosses involving Indian commercial hybrids, the best family was CoC 671 x Co 99002 with a maximum record value of 25.0% brix and contributed more than thirtyfive percent selections performing better than the cross average. In the crosses between Indian and exotic hybrids, two crosses *viz.,* PR 1080 x Co T 8201 and PR 1080 x Co 94008 recorded a maximum of 23.4 % brix contributing more than twenty percent selections with high juice brix. These results correlate with the earlier findings of Nair *et al.* [12] in an extensive collection of exotic hybrid germplasm representing ten geographical groups.

Clonal evaluation of the first cycle hybrids for early high sugar content

In the present investigation, 472 genotypes identified for early high juice brix were clonally evaluated along with four early standards for comparison. Twenty clones failed to establish due to poor germination. Juice analysis

Table 1. Cross performance for juice brix in the first generation progenies

Cross	No. of seedlings evaluated	H.R. brix (%)		H.R. brix(%) range	Cross mean	% individuals with +1 unit above cross mean
		Female parent	Male parent			
Co 285 x Co 775	250	20.20	20.00	14.0-21.6	19.02	19.23
Co 7201 x Co 62198	260	19.60	20.50	15.0-23.6	20.74	28.57
Co 86002 x Co 7915	260	21.00	19.60	14.4-22.6	19.52	32.14
Co 85002 x CoT 8201	245	19.20	19.40	12.4-23.0	19.74	22.86
Co 97007 x Co 775	260	19.40	20.00	14.2-22.0	19.06	20.83
Co C671 x Co 99002	220	21.50	19.60	12.0-25.0	21.99	35.21
Co C671 x Co 94008	230	21.50	18.50	16.0-23.0	20.02	20.41
Co C671 x CoT 8201	250	21.50	19.40	18.2-23.0	19.42	16.67
Co 86010 x CoT 8201	270	20.50	19.40	16.0-22.4	19.04	31.22
CP 52-1 x CoA 7602	220	20.40	20.00	14.2-22.0	19.22	18.18
CP 49-50 x Co 94008	260	21.50	18.50	14.6-23.2	20.04	11.43
PR 1080 x Co 94008	220	20.50	18.50	16.0-23.4	20.24	25.50
PR 1080 x CoT 8201	220	20.50	19.40	18.0-23.4	19.80	23.80

data at 300 days of crop age indicated the potential clones to be advanced for further intermating. The performance of the top ten selections for juice brix in cycle I is presented in Table 2. Among the check varieties, CoC 671 was the best with a mean sucrose of 19.46% followed by Co 2000-03 with 18.6%. The juice brix values of the first cycle hybrids ranged from 16.0% to 25.0%. The best clone 02-071 recorded the highest juice brix of 25.0% and 23.06% sucrose, respectively. One hundred and four hybrids recorded more than 23% brix and was identified as early high brix clones and all the flowering types were advanced to the next selection cycle.

Table 2. Performance of top ten selections for juice brix at ten months in cycle I

Clone No.	Brix (%)	Sucrose (%)	CCS (%)	Parentage
02-071	25.00	23.06	16.27	Co 7201 x Co 62198
02-094	24.80	22.96	16.22	CP 49-50 x Co 94008
02-137	24.80	22.90	16.16	Co 97007 x Co 775
02-230	24.60	22.64	15.95	Co 86002 x Co 775
02-295	24.20	22.28	15.70	CoC671x CoT8201
02-310	23.80	21.58	15.11	CoC671x CoT8201
02-033	23.40	21.42	15.06	Co 285 x Co 775
02-061	23.20	21.28	14.97	Co 7201 x Co 62198
02-314	23.10	21.10	14.82	CoC671x Co 99004
02-244	23.10	22.40	14.76	PR 1080 x CoT 8201
Check				
CoC 671	23.60	19.46	13.00	
Co 2000-03	22.00	18.60	12.59	

In order to quantify the progress made in cycle I, the per cent improvement for sucrose percent over the best check variety CoC 671 was estimated in these clones. Five clones *viz.*, 02-071, 02-094, 02-137, 02-230 and 02-295 registered more than ten percent improvement over CoC 671 for juice sucrose (Fig. 1). The improvement made for juice brix in the first cycle was substantial with a maximum of 25%. Kennedy [11] from West Indies Central Sugarcane Breeding Station, Barbados reported that the new high quality parents identified from their recurrent selection programme for high sucrose had generated over eighty percent elite families. It was also observed that by the second cycle of selection, the population had begun to show a shift towards higher brix. The maximum of 30% brix at cycle four is about 27% better than their standard variety B77602.

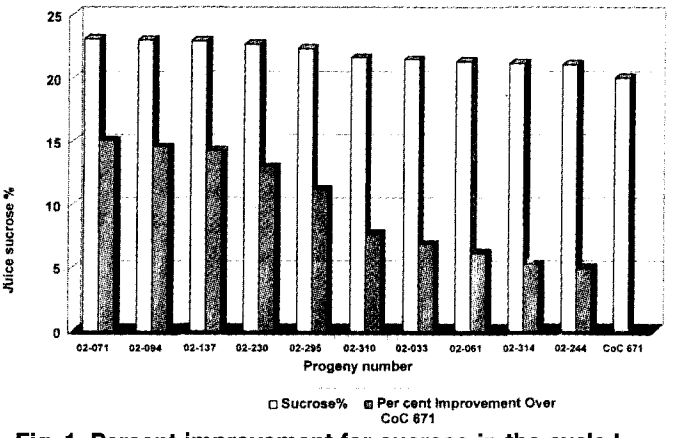

Fig. 1. Percent improvement for sucrose in the cycle I hybrids

Table 3. Frequency of red rot resistant clones in the cycle I hybrid population

Cross	Clones tested	No. of MR clones*
Co 1254 x Co 775	4	3
Co 7201 x Co 62198	5	4
Co 86002 x Co 62198	2	2
Co 86002 x Co 79 15	11	3
Co 85002 x CoT 8201	5	4
Co 88028 x Co 86011	8	3
CoC671 x Co 94019	3	1
CP 49-50 x CoT 8201	4	3
CP 49-50 x CoA 7602	2	2
PR 1 080 x Co 94008	2	1

*CCT method

Evaluation of high sucrose clones for red rot

Since selection was for a single trait *viz.*, juice brix, variation for other characters has been presumably retained in these populations. Relying on a restricted gene source for quality might favour the retention of deleterious character such as disease susceptibility. This could deny the benefits of using the very high quality clones in other breeding programmes. Hence, an attempt was made to screen these clones for their reaction to red rot pathogen *viz.*, *Colletotrichum falcatum* Went, by CCT (Controlled Condition Testing) method against tropical isolates (CoC 671 and CoC 90063). Out of seventy three high sucrose clones tested, thirty six clones were found to be moderately resistant (MR). The frequency of moderately resistant clones in the crosses involving high sucrose genotypes is presented in Table 3. The crosses *viz.*, Co 7201 x Co 62198, Co 85002 x CoT 8201 and CP 49-50 x CoT 8201 contributed more clones combining high sucrose and resistance to red rot. These selections could be a potential source in future breeding programmes targeting to combine these two traits *viz.,* high sucrose and resistance to red rot.

Inferences

Given the constraints on area and yield, the most cost effective way is to increase the sugar content of the varieties. Hence, it becomes essential to build up parental populations capable of accumulating high levels of juice sucrose. The result from the present study indicates the potential of realizing high sucrose clones as the selection cycle advances. Thus, clones identified from the cycle I in the present study for their early high sucrose content are expected to contribute to a more rapid genetic progress when used in breeding programs.

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