Research Article

Development of pre-breeding stocks with improved sucrose content over two selection cycles in sugarcane

R.M. Shanthi and S. Alarmelu,

Abstract

In a base population comprising twenty three Indian "Co" canes and fourteen commercial hybrids from other countries, improvement in sucrose content was obtained over two cycles of recurrent selection. The parental clones had an average sucrose of 19.40%. Among the crosses involving Indian commercial hybrids, the best was CoC 671 x Co 99002 with a maximum record value of 24.0% brix and contributed more than thirty five per cent selections performing better than the cross average. In the crosses between Indian and Foreign hybrids, two crosses viz., PR 1080 x CoT 8201 and PR 1080 x Co 94008 were the best with 23.4% brix which gave more than 23 per cent selections with high juice brix. The cycle I hybrid progenies had juice sucrose values ranging from 17.0% to 23.0% with a mean of 21.6%. The cycle II progenies recorded average juice sucrose of 22.0% with 13.40% improvement over base population. After two cycles of selection, the progress made for sucrose content in comparison with the base population is substantial. Combined evaluation of 472 high sugared clones identified from cycles I and II indicated potential pre-breeding stocks with early high sugar content which could be exploited in future. The clones 00-0402, 00-1805, 01-0031, 01-0047, 02-0288 recorded more than eight per cent improvement in sucrose content over the zonal check variety CoC 671 under early maturity group.

Key words: Recurrent selection – breeding stocks - high sucrose – sugarcane.

Introduction

Breeding population in sugarcane tends to show a steady improvement for cane yield and there have been very little increase in juice sucrose content for several decades. An improvement in sugar content of sugarcane increases sugar yields with only a marginal increase in costs of production. This makes gains in sugar content economically more beneficial than corresponding increases in cane yield, means that increased sugar content is an important objective of sugarcane breeding programs (Jackson, 2005). However, comparisons of cultivars released in different years indicate that sugarcane breeding programs have delivered increased sugar yields via improvements in cane yield, with much smaller contributions from sugar content. During the 1990s, a project at the WICSBS led to significant advances in the breeding of varieties with enhanced sugar yield.

Division of Crop Improvement, Sugarcane Breeding Institute, Coimbatore-7.

This was achieved by developing a special breeding population with extremely high sucrose content. Studies in Lousiana breeding population to improve sugar yields via indirect selection in the first clonal testing stage of sugarcane (*Saccharum* spp.) improvement programs indicated selection emphasis based on high juice brix and low pith increased sucrose content. Maintaining high levels of sucrose content in high cane-yielding selections should best increase sucrose yield. (Gravois *et al.*, 1991). Successful efforts to improve sucrose content through the adoption of different selection strategies, coupled with the choice of appropriate parents, have been reported in many countries (Legendre, 1995). Despite attempts through conventional and molecular breeding, the stored sugar concentration in elite sugarcane cultivars has not been increased for several decades. A more strategic breeding approach is underway at the Sugarcane Breeding Institute, Coimbatore to enhance the juice sucrose levels of sugarcane cultivars through a simple recurrent selection scheme. The main objective of the study is to generate a group of clones that has brix and sucrose concentration outside the range of existing

comercial hybrid clones in sugarcane. Selection right from ground nursery was made rigidly for juice brix alone, ignoring all other characteristics. The results presented in this paper comes 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 twenty five Indian commercial hybrids (Cocanes) and twelve foreign hybrids with juice sucrose of ≥19.0 % at 12 months of crop age. Starting from a base population of 37 high sucrose clones, a simple recurrent selection scheme was adopted. All the thirty seven parental clones were planted in a separate crossing block for hybridisation purpose. Thirty biparental crosses were attempted involving eighteen Indian Cocanes and eight foreign hybrids. 5420 seedling progenies were planted with ten seedlings / row of 6 meter length and rows 0.9 meter 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.

1290 hybrid progenies recording ≥ 21.0% H.R. brix were selected from ground nursery and planted in a stage I selection trial i.e. first clonal trial (with 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. Three cane samples from each progeny were crushed and analysed for total solids in the juice.

Top thirty high sucrose selections that are flowering types from cycle I were advanced for further intermating. Based on synchrony among the flowering types, fifty *inter se* crosses were attempted during 2006 flowering season. 4800 cycle II hybrid progenies were evaluated in ground nursery and 1100 selections with more than 23.0 % juice brix were forwarded for second clonal evaluation. From the first clonal evaluation of cycle I and cycle II progenies, 72 clones performing better than the best check variety for juice sucrose viz., Co 2000-03 were selected and planted in Final clonal trial in an RBD 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 meter length spaced at 0.9 meter between rows. Juice quality characters were determined at tenth month of crop duration. Five whole cane stalks were sampled from each clone and given 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.

Results and Discussion

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 ≥ 21.0%. In a seedling population derived from 63 biparental crosses with parents differing in their sucrose content Hsu *et al.*, (1995) 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% (Table 1). Earlier studies on systems of selection by Ramana Rao *et al*. ,(1983) at the Sugarcane Breeding Institute has indicated the following families viz., CoC 671 x MS 68/47, Q68 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. Among the crosses involving Indian commercial hybrids, the best family was CoC 671 x Co 99002 with a maximum record value of 24.0% brix and contributed more than thirty five per cent selections performing better than the cross average. In the crosses between Indian and Foreign hybrids, two crosses *viz*., PR 1080 x Co T 8201 and PR 1080 x Co 94008 recorded a maximum of 23.4 % brix contributing to more than twenty per cent selections with high juice brix. These results correlate with the earlier findings of Nair *et al*., (1998) in an extensive collection of exotic hybrid germplasm representing ten geographical groups. Their studies have indicated that nearly forty per cent of the Puerto Rican (PR) varieties recorded more than 19%

sucrose. It was suggested that the Puerto Rico (PR) group is the best group for juice sucrose and could be exploited as potential donors in juice quality improvement programmes.

Combined evaluation of Cycle I and Cycle II hybrid clones

Seventy two clones from cycles I and II were tested in a replicated trial to identify clones capable of accumulating high levels of sucrose at early stages of crop maturity. Three early standards viz., Co 85004, Co 2000-03 and CoC 671 were included for comparison. Juice analysis was conducted at 240 days of crop age. Among the checks, CoC 671 recorded a mean sucrose of 18.89% followed by Co 2000-03 with 18.84%. The clone 00-0402, a cycle I hybrid recorded a maximum of 21.71% sucrose registering 14.93% improvement over the best check CoC 671 (Table 2). Two clones viz., 01-0047 and 02-0288 recorded more than 21.05% juice sucrose and 12% improvement over CoC 671. Eleven clones recorded more than 19.0% juice sucrose with more than 5 % improvement over CoC 671.

Improvement in sucrose content over two selection cycles:

The base population comprised of twenty Indian Cocanes and fourteen foreign hybrids. The parental clones had an average sucrose of 19.40%. The cycle I hybrid progenies had juice sucrose values ranging from 17.0 % to 23.0% with a mean 21.6%. The cycle II progenies recorded average juice sucrose of 22.0% with 13.40% improvement over base population (Fig.1). After two cycles of selection, the progress made for sucrose content in comparison with the base population is substantial.

Evaluation of high sugared clones at periodic intervals:

Fifteen high sugared clones from cycles I and II were assessed for their sugar accumulation at periodic intervals (Fig.2). Six clones maintained a steady improvement in their sucrose content in comparison with the check CoC 671 from 240 days to 300 days. Four clones viz., 00-1101, 00-1111, 00-1805 and 02-0041 registered more than twelve per cent improvement for juice sucrose per cent over CoC 671 and two other clones viz., 00-0404 and 00-0202 recorded 9.20 % and 6.49 % improvement over CoC 671 at 360 days. While two clones 01-0089 and 01-0047 recorded a sharp decline in their sugar accumulation after 300 days. The clone 01-0089 recorded a six per cent improvement over CoC 671 from 240 to 300 days and it was only 1.86% improvement at 360 days. The other clone 01-0047 registered only a minimal gain in sucrose content (0.43%) at 360 days.

Progeny performance of cycle II hybrid clones

Five hundred progenies from crosses involving three high sugared clones (02-0295, 01-0030 & 00-0094) from cycle I were assessed. The best progeny from the cross 02-0295 x 99-0075 had 23.4 % brix and 21.0% sucrose at 240 days while the check variety CoC 671 recorded only 19.4% brix and 18.00 % sucrose respectively with 15% improvement over the check variety. Two progenies from the crosses 00-0094 x 02-0071 and 01-0030 x 02-0288 recorded an average brix of 23.00% and 20.80% sucrose.

The clone 02-0288 is an early high sugared clone from cycle I with a pollen fertility of 85% and flowers heavily during mid November. Progeny performance of this clone was studied in the derivatives from four different crosses involving 02-0288 as male parent. A total of 360 progenies were assessed for their juice brix at 240 days. Brix values of the progenies ranged from 18.40 to 26.0% with a population mean of 21.99%. Out of four crosses involving 02-0288, two crosses *viz*., 01-0047 x 02-0288 and 02-0270 x 02-0288 registered a mean juice brix of 22.29% and more than twenty five per cent of the population had brix values above the cross average at 240 days.

Inferences

After two cycles of selection, a set of clones with brix and sucrose outside the range of existing commercial varieties have been generated. Promising selections for high brix made in the cycle II would become the parents in cycle III. The cycle II progenies recorded average juice sucrose of 22.0% with 13.40% improvement over base population. At the end of two selection cycles, the progress made for sucrose content in comparison with the base population is substantial. The clone SCGS 00-0402 was registered with Plant Germplasm Registration, NBPGR as an early high sugar clone with high commercial cane sugar per cent. Thus, clones identified from the cycle I and II in the present study for their early high sucrose content could serve as potential parental clones in sugarcane breeding programmes.

References

Gravois, K. A., S. B. Milligan and F. A. Martin 1991. Indirect selection for increased sucrose yield in

early sugarcane testing stages, Field Crops Research, 26 (1), 67-73.

Hsu, S.Y., Hour, A.L. and Wang, T.H. 1995. Heritability and modes of inheritance of brix in sugarcane seedlings. Proc. Intl. Soc. Sugar. Technol. 22: 286-292.

Jackson, P.A. 2005. Breeding for improved sugar content in sugarcane. Field Crops Research, 92 (2-3), 277-290.

Legendre, B.L. 1995. Potential of increasing sucrose content of sugarcane varieties in Louisiana through breeding. Proc. Int. Soc. Sugar Cane. Technol: 21, 367-377.

Ramana Rao, T.C., Balasundaram, N. and Satish Rao, C. 1983. Systems of selection. Sugarcane Breeding Institute. Annual Report, 32-35.

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

Cross	H.R. brix Range	Cross mean	% individuals with +1 unit above cross mean
Co 285 x Co 775	14.0 – 21.6	19.02	19.23
Co 7201 x Co 62198	15.0 – 23.6	20.74	28.57
Co 86002 x Co 7915	14.4 – 22.6	19.52	32.14
Co 85002 x CoT 8201	12.4 – 23.0	19.74	22.86
Co 97007 x Co 775	14.2 – 22.0	19.06	20.83
CoC 671 x Co 99002	12.0 – 25.0	21.99	35.21
CoC 671 x Co 94008	16.0 – 23.0	20.02	20.41
CoC 671 x CoT 8201	18.2 – 23.0	19.42	16.67
Co 86010 x CoT 8201	16.0 – 22.4	19.04	31.22
CP 52-1 x CoA 7602	14.2 – 22.0	19.22	18.18
CP 49-50 x Co 94008	14.6- 23.2	20.04	11.43
PR 1080 x Co 94008	16.0 – 23.4	20.24	25.50
PR 1080 x CoT 8201	18.0 – 23.4	19.80	23.80

Table 2. Juice analysis of high sucrose clones at 240 days

CLONES	Mean Sucrose %	Per cent improvement. Over CoC 671	Per cent improvement Over Co 85004
00-0402	21.71	14.93	15.23
01-0047	21.34	12.97	13.27
02-0288	21.19	12.18	12.47
00-1805	20.57	8.89	9.18
01-0031	20.55	8.79	9.08
99-0075	20.06	6.19	6.48
00-1004	20.01	5.93	6.21
00-1801	20.02	5.98	6.26
01-0046	19.89	5.29	5.57
01-0062	20.13	6.56	6.85
01-0158	20.55	8.79	9.08
02-0294	20.06	6.19	6.48
01-0024	19.86	5.13	5.41
CHECKS			
CoC 671	18.89		
Co 2000-03	18.84		
Co 85004	18.39		

Table 3. Progeny performance of 02-0288 from cycle I

Cross	Mean brix%	% progenies above cross mean
00-1805 x 02-0288	21.99	23
02-0270 x 02-0288	22.09	29
01-0047 x 02-0288	22.29	30
01-0030 x 02-0288	21.60	13

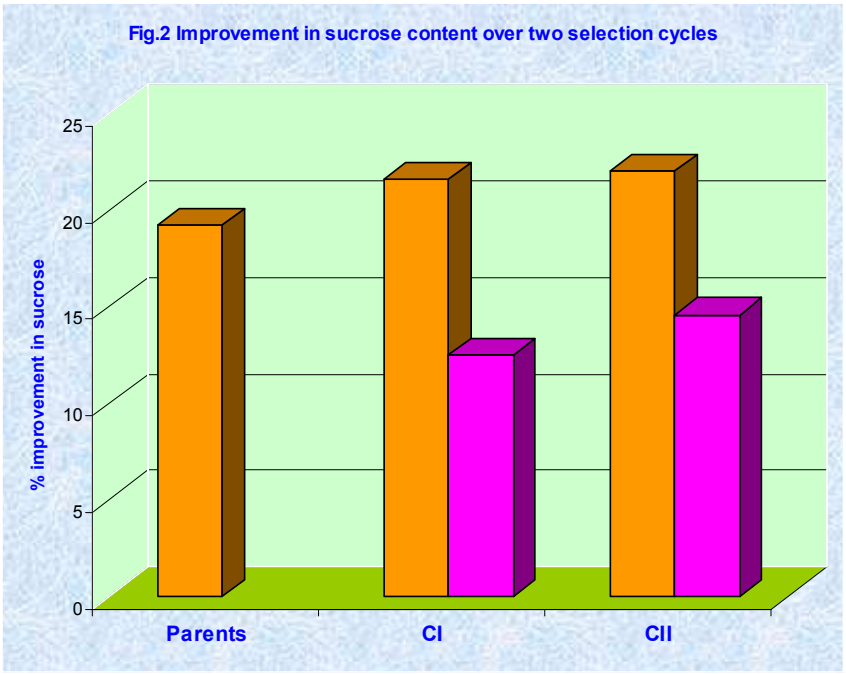
Fig.2 Improvement in sucrose content over two selection cycles
% improvement in sucrose
25
20
15
10
5
0
Parents
CI
CII

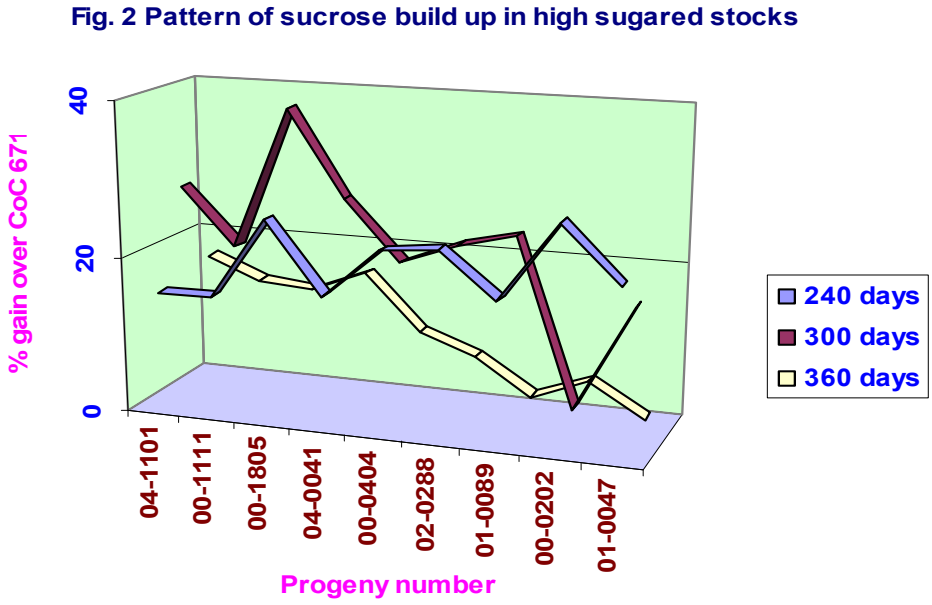
Fig. 2 Pattern of sucrose build up in high sugared stocks
% gain over CoC 671
40
20
0
04-1101
00-1111
00-1805
04-0041
00-0404
02-0288
01-0089
00-0202
01-0047
Progeny number
240 days
300 days
360 days