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RESEARCH ARTICLE :

Variability trends for brix content in general cross combinations of sugarcane (Saccharum Spp.)

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SUMMARY : The study was undertaken to determine the potential of general cross combinations in sugarcane, obtained by open pollinating the female parents to generate variants for brix (per cent total soluble solids) content and frequency distribution pattern of variants, hence generated. Using Brix (an indicator of sucrose content) as selection criterion, 1436 ratooned seedlings raised from 5 general cross combinations, comprising high sugared commercial varieties of peninsular zone as female parents *viz.*, 97 R 129, Co 7219, Co 98008, 87 R 40 and Co A 7602 were investigated. The adjusted brix values of test genotypes, evaluated in augmented incomplete block design, inferred the generation of highly variable population with significant differences in test genotypes. Further cross wise evaluation revealed that progeny means of three General combinations raised from female parents Co 7219, 97 R 129 and 87 R 40 were significantly higher than respective parental means, whereas, the progeny obtained from high sugared female parents Co A 7602 and Co 98008 has significantly lower mean brix value than parental means, thereby signifying that determining the combining ability of parents is important to generate elite segregants since some parental combinations may not be able to transfer their potential economic values (traits) to next generation. Highly significant negatively skewed leptokurtic distribution of the progeny for brix content in General combinations obtained 97 R 129 and Co 7219 indicated that the tail on the left side of probability density function was longer than the right side and the bulk of the values (including the median) lie to the right of the mean. This indicated that 97 R 129 & Co 7219 are potential female parents to generate high frequency of elite seedlings for Brix. The evaluation of elite clones from General combinations in the next Clonal stage (Settling I) led to a higher selection rate in 97 R 129 & Co 7219 as compared to other General combinations. The study suggested the scope of general cross combinations, which are less laborious, cost effective and generally yield more fuzz, to generate elite segregants for qualitative traits like sucrose content in sugarcane. The influence of female parents on frequency distribution pattern of elite segregants has been discussed.

KEY WORDS :
Variability, Brix, Combinations, Sugarcane

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BACKGROUND AND OBJECTIVES

Modern sugarcane (Saccharum spp. Complex) is an important grass that contributes 60% of the raw sugar produced worldwide and has a high biofuel production potential. It was created about a century ago from the combination of the polyploidy species

S. officinarum, the domesticated sugar-producing species with X=10 and 2n=8x=80 and *S. spontaneum*, a vigorous wild species with x=8 and 2n=5x=40 to 16x=128 and many aneuploid forms (D' Hont *et al.*1995). Proper exploitation of variability in a crop like sugarcane with a complex ploidy and a high level of heterozygosity is a complicated process (Babu *et al.*, 2009). Improvement in genetic potential for stalk and sugar yields is the most important objective in sugarcane breeding programme. The main difficulty in improvement of sugarcane is selection at seedling stage. Further, it is a vital stage of selection because it provides the base population for remaining and more effective stages of selection (Ram Bakshi, 2009). Selection is applied in all breeding stages: the choice of parents, cross combinations and the plant population originating from the crosses made. Selection at early stages in sugarcane breeding programmes is generally based on refractometer brix as the only juice quality characteristic. Many breeders indicated that heritability of juice quality in sugarcane, including brix, is moderate to high and therefore can be improved with the correct selection pressure. Brix was highly correlated with sucrose and selection for high sucrose could begin as early as the single stool stage and most of the genetic variation for brix could be attributed to additive effects. Selection for sugar productivity is inefficient in the first Clonal generations; breeding programs have conducted parallel selection studies based on the selection of superior families (Barbosa *et al.*, 2004, Barbosa *et al.*, 2005).in the early stages of selection, the strong effect of the environment on the genotypes of sugarcane evaluated is responsible for the low heritability estimates found in these stages (Skinner *et al.*, 1987).

Recognizing ratoonability as an important trait in sugarcane varieties, selection in ratoon seedlings is warranted, particularly in subtropical countries where seedlings remain immature at the time of next seasons planting and hence, may not express their full potential (Ram Bakshi, *et al.*, 1997). After several cycles of crossing and selection in a generation-wise crossing programme, gain in performance becomes smaller & more difficult to detect. Therefore, improving the efficiency of selection that generates genetic gains is important. Brix was highly correlated with sucrose and selection for high sucrose could begin as early as the single stool stage and moreover, most of the genetic variation for brix could be attributed to additive effects. The main objective of the experiment was to investigate the potential of general cross combinations which are not laborious to execute like bi-parental crosses in sugarcane and to elite segregates in the population for brix value, a trait of high heritability and an indicator of sugarcane quality.

RESOURCES AND METHODS

5 general cross combinations were effected from open pollinated subtropical female parents sown in same block at national hybridization garden (NHG), sugarcane breeding institute Coimbatore, India in 2014. The subtropical or tropical parents refer to variety/clone/ cultivar adapted to respective zone. In general cross combinations, female parents were allowed to open pollinate and fuzz was hence, collected from female arrows. The seedling stage refers to a selection stage where clones are grown from true seed (fuzz) after hybridization and the subsequent stage that develops from regeneration of the seedlings clumps after harvest, is referred to as ratooned seedling stage. After germination tests, the fuzz was sown under polytunnels with high humidity in April, 2015. Three month-old seedlings were transplanted during July 2015 in the ground nursery at an equal distance of 50 cm between the seedlings in each of 6m row length, spaced at 150 cm. the experiment was established as an augmented incomplete block design along with one-month old settlings of four checks *viz.*, (co 86032, Co C671, 85 R 186, 83 R 23) (commercial varieties) along with maternal parental clones in each block. The seedlings were harvested after 300 days of transplanting and the crop was ratooned using standard cultural practices followed in the Telangana State. 1436 number of ratooned seedlings derived from different crosses was evaluated for brix using a hand refractometer after 270 days of ratooned and reported. The brix was recorded from two shoots of a clone and the average brix from the two sub samples were used for each cross and hence, the class intervals were constituted for brix. The frequency distribution of progeny for brix content for each general cross combination was determined and represented graphically. The elite clones from each general cross were promoted to stage I based on brix content and other cane traits in 2016 and the data on per cent selection has been discussed briefly.

OBSERVATIONS AND ANALYSIS

The ratooned seedlings were evaluated in an

augmented design using adjusted values of brix as the selection criterion. The critical differences and standard error of deviation for a total of 1436 test genotypes (irrespective of type of crosses) within blocks, between blocks and between control and test treatment were presented in Table 1. The heterogeneity was observed within blocks. The treatments were, therefore adjusted and compared using respective critical differences. Highly significant differences in the test genotypes for brix content indicated the generation of highly variable population from general cross combinations in sugarcane. In augmented design, the standard varieties were planted in each block and thus replicated, while the test entries were not. Because the design is non-replicated for the test clones, the repeated checks were used to estimate the error mean square and the block effects. The estimated block effects were used to adjust the observed values of test entries. The comparative utility and efficiency of augmented randomized block design over incomplete block designs, namely the rectangular lattice and cubic lattice in the Clonal evaluation trials in sugarcane inferred that the top 10 % selection base on statistical analysis remained almost the same in both the designs. The augmented design, though not equal to lattice design in statistical efficiency, is quite useful to sugarcane breeders who have to evaluate a large number of clones as precisely as possible. Though the analysis of augmented design provided for elimination of block effects in respect of each genotype, there seemed to be no possibility of further reduction of error variance as in lattice design. The highest values of LSD and C.V. are usually recorded in case of augmented design (Bagyalakshmi and Somarajan 1999).the adjusted brix values were used further for cross wise progeny evaluation.

Table 2: described the comparison of parental mean with the respective progenies originated for each GC. In GC I, II, III originated from 97 R 129, Co 7219, and 87 R 40 the mean value of the progenies were significantly higher than the parental means, thus inferring the potential to generate good segregants for brix. As expected, the variance was higher in the progeny as compared to

Table 1 : Analysis of variance for Brix value of the progenies based on augmented design

SOV	Df	SS	MS	F	Prob>F
Block	40	35.85	0.835	1.351	0.058
Treatments (adjusted)	1436	4941.76	5.645	9.416	0.000
Error	140	89.62	0.670		
Total	1616	5067.23			

Parameters	Standard error of deviation (SEd)	Critical difference (1%)	Critical difference (5%)
Two control treatments	0.1962	0.5902	0.4330
Two test treatments (same block)	1.437	3.319	2.632
Two test treatments (different block)	1.464	3.451	2.884
A test treatment and a control treatment	0.9478	2.744	1.898

Table 2 : Comparison of mean and variance in the female parental clones and respective progenies originated in General cross combinations of sugarcane

Items	Brix (%) in female parent	Brix (%) in progeny originated
GC I (97 R 129) mean (t- value)	18.52	20.14 (2.51)
Variance	0.42	3.78
GC II (Co 7219) mean (t- value)	18.87	20.42 (2.23)
Variance	0.49	5.25
GC III (87 R 40) mean (t- value)	17.40	17.63 (5.43)
Variance	0.35	5.87
GC VI (Co A7602) mean (t- value)	20.09	16.19 (-3.19)
Variance	1.64	6.67
GC V (Co 98008) mean (t- value)	21.07	17.88 (-2.45)
Variance	1.76	7.28

Table 3 : Descriptive statistics for HR Brix in progeny of different general cross combinations

General cross combinations	Total number of seedlings generated	mean	minimum	maximum	median	Co-efficient of variance
97 R 129	298	20.14	13.0	23.0	18.4	12.38
Co 7219	369	20.42	14.0	23.0	18.6	14.19
87 R 40	435	17.63	7.40	23.0	19.0	14.77
Co A7602	218	16.19	10.0	22.0	19.8	14.09
Co 98008	116	17.88	12.0	21.0	19.0	14.20

Table 4 : Performance of progeny in different general cross combinations

	Per cent poor seedlings/population (< 16.0 HR brix)	% average seedlings/ population (16.1- 20.0 HR brix)	% Elite seedlings/ population (> 20.1 HR brix)
97 R 129	17.18	60.83	21.99
Co 7219	15.75	62.90	21.35
87 R 40	21.83	56.55	20.59
Co A7602	32.36	58.32	9.32
Co 98008	49.39	43.09	7.53

parents in all general cross. General cross IV and general cross V were originated from high sugared elite varieties *viz.*, Co A 7602 and Co 98008 having mean values 20.09 and 21.07, respectively. Their progenies were recorded with significantly lower mean values for brix in comparison to parental mean *i.e.*, 16.19 &17.88, respectively.

The general statistics for each type of general cross combination *viz.*, 97 R 129 (GCI), Co 7219 (GCII), 87 R 40 (GCIII), Co A 7602 (GCVI), Co 98008 (GCV) were described in Table 3. The mean brix was 17.88 in progeny of GC V followed closely by that of GC IV & GC III with a brix value of 16.19 &17.63, respectively. In GC I, II, IV, &V none of the seedlings has brix value lower than 10.0 whereas in GC III the lowest limits of the variants were 7.40. Not much difference was observed in co-efficient of variance in all general cross combinations (14.09 in GC VI to 14.77 in GC III) except in GC I (12.38).

. Based on brix value, the categorization of seedlings in three classes *viz.*, poor (< 16.0 brix content), average (16.1 - 20.0 brix content) and elite (> 20.1 brix content), was done (Table 4). 97 R 129 GC generated the highest per cent elite (21.99) seedlings followed by Co 7219 GC (21.35), 87 R 40, Co A 7602, Co 98008 and generated 20.59, 9.32 and 7.53 per cent elite seedlings having brix content > 20 per cent, respectively.

In sugarcane breeding, the numbers of superior individuals in a cross are very important because thousands of progenies are available for testing, parents are chosen for further crossing on the basis of high sample mean and or high sample variance in the progeny for the traits under consideration (Shanthi *et al.*, 2005).the brix % was taken as selection criterion as this trait has high repeatability over generations. Brix % cane juice presented high repeatability values between stages 1 and 11 and also between plant-cane and first-ratoon crops. Particularly for this trait, individual selection can be intensified in stage 1. The availability of objective data on progeny performance present the opportunity to generate robust estimates of the breeding value of parents involved in crosses. The evaluation at ratooned seedling stage has added advantage of selection for ratoonability as well. Better ratoonability, when harvested during winter months, is an important trait of sugarcane clones in tropical zone and this would be improved by increasing the selection intensity in seedling ratoon nursery.

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