Original Research Article

Evaluation of Superior Cross Combinations and Identification of Better Parental Stocks from Early Clonal Trials In Sugarcane

ABSTRACT

Sugarcane is a clonally propagated crop and genetic improvement involves crossing of diverse species of *Saccharum* clones. Identification of desirable cross combination is one of the essential step in the development of superior varieties. This study was conducted with an objective of identification of best cross combination based on their ability to produce superior clones by contributing desirable traits and suitability of a parental stock as "FEMALES" or "MALES" based on their ability to transmit positive genes to progeny. Sixteen biparental crosses with minimum of 20 progenies were screened for NMC (≥10) and HR Brix (≥20 units) in first clonal selection. The significance of parental stocks performance in cross combination was tested using "t" test assuming unequal variance. Progenies obtained from Co 06015, Co 0241 and Co 8347 recorded 20.99%, 20.82% and 20.81% of HR Brix, while Co 0209, Co 06015 and Co 94008 recorded 14.23, 12.76 and 11.88 of mean NMC when they used as male in crossing. Clones derived from Co 99006, Co 0403 and Co 06002 showed 20.93%, 20.82% and 20.81% of HR Brix, whereas Co 07010, Co 99006 and 2007-285 recorded 13.68, 12.21 and 11.40 mean NMC when they were used as female in crossing. Crosses viz., Co 99006 x Co 06015, Co 0403 x Co 0241, 2007-285 x Co 0209 and Co 94005 x Co 86011 has contributed 63%, 32%, 30% and 28% desirable selections respectively. The clones Co 06015 and Co 99006 are proven male and female can be used abundantly in crossing for the development of superior clones. The clones Co 8347, Co 0241, Co 0209 and Co 94008 are best males, whereas Co 0403, Co 06002, Co 07010 and 2007-285 are best females need to be crossed extensively for the development of superior varieties combining quality and cane yield traits.

Ker words: Saccharum, Sugarcane, Hybridization, Females, Males, Progeny, Cross combination, T-test

1.INTRODUCTION

Sugarcane (*Saccharum spp*.) is a major crop grown in tropical and subtropical nations, where its been cultivated for various industrial products like sugar, waxes, biofuels, bio-fiber, biomass and cogeneration. The development of sugarcane variety having all the cane and juice parameters to suit varied climatic conditions of the country like India is a herculean task [1,2]. The present sugarcane varieties are evolved from noble canes (*Saccharum officinarum*) crossed with a wild grass species *Saccharum spontaneum* over a period of time with the continued and systematic introgression with other species of the *Saccharum* complex [3,4]. India is one of the primary centers of origin/ diversity and the crop has been in cultivation in the subcontinent since time immemorial for its products like brown sugar, jaggery, molasses, live fencing and as fodder to the cattle [5,6,7]. Prior to the dawn of nineteenth century, commercial sugarcane cultivation includes clones of *Saccharum officinarum*, *S. barberi* and *S. sinenss* [8,9,10]. The selection indices adopted over a period of time has changed with the advent of modern agriculture in the early part of nineteenth century [11,12]. Chilton et.al, (1956) while working at Louisiana state university and Anzalone et. al, (1961) enlisted the selection indices like vigor, cane diameter, cane length, number of canes (NMC) and Brix are the most important traits to be considered while selecting a superior clone. Before a variety is released for commercial cultivation, it needs to meet certain minimum requirements, those include quality parameters (juice brix, sucrose, juice purity and extraction percent), yield parameters (number of millable canes, single cane weight and cane length), resistance/tolerance to biotic factors (red rot, smut, Pokkah boeng, borers, white grub and other minor pests, abiotic factors (drought, salinity and water logging) and stability for yield traits over seasons, locations and in plant and ratoon crops.

Sugarcane is a clonally propagated crop and genetic improvement involves crossing of diverse species of *Saccharum* clones for the development of superior progeny [13]. The success of the cross depends on the choice of parents involved. The parents combined capacity to yield quality offspring and their individual performance in terms of sugar concentration, adaptability, agronomic traits, disease and pest resistance, and other qualities can be used to determine the parents' relative value. The most effective way to select individual clones was to combine brix testing with visual yield grade testing for clones that had passed [14]. Once a clone is developed by crossing desirable parental combinations, it can be maintained for years without any appreciable decrease in the vigor and vitality of clone through vegetative propagation. The new generation breeding tools involving molecular techniques are not well established in sugarcane development due to polyploidy nature of crop and presence of numerous aneuploid gametes during segregation, which might be the reasons for the lack of effectiveness of these tools in sugarcane crop [15,16,17]. In this backdrop it is imperative to have pool of superior parents to use them in crossing programme for varietal development. The selection of parents for a trait of interest should be based on the proven performance in terms of their ability to contribute desirable traits to the progeny in the form of production of higher number of desirable clones over a period of time [18,19,20]. Another important aspect while selecting the parent is its utility as a male or female parent in the crossing programme. Many important parents are successful either as male or female only [21]. This trait can be ascertained by parental contribution to the progeny when used in reciprocal crossing for the quality and yield. Based on this the parents can be grouped accordingly to be used for the development of superior varieties [12].

2. MATERIAL AND METHODS

The experimental material for the present study consists of 16 biparental crosses with a minimum of 20 progenies from each cross, which were selected randomly from the ground nursery and were planted five clones per row in a first clonal trial during 2017-18 and ratooned in 2018-19. The progenies were scored for a major yield parameter viz. NMC and quality traits in terms of H.R Brix in the ratooned trial at the end of season for selecting the best selections and thereby leading to the identification of the best parental stocks and potential cross combinations. The indices employed to select and promote clones to next level (second clonal stage) was NMC (≥10) and H R Brix (≥20 units).

Table 1: Cross combinations used for screening population for NMC and HR Brix in ground nursery

Sl No.	Cross combination		NMC ('000/ha)			HR Brix%		
		Pop size	Mean	Range	SD	Mean	Range	SD
1	2007-285 x Co 0209	20	15.2	2-23	5.61	19.34	13.7 - 24.0	3.06
2	Co 07010 x Co 0209	35	13.68	2-28	5.39	18.96	15.4 - 21.8	1.67
3	2007-291 x Co 2010-03	50	8.16	1-13	3.10	19.36	13.4 - 24.0	2.69
4	2007-291 x Co 07010	20	13.50	7-19	4.19	19.21	16.4 - 23.0	2.06
5	Co 94012 x Co 94008	70	12.27	1-23	5.03	18.64	12.5 - 24.2	3.08
6	Co 0403 x Co 0241	25	10.36	5-21	3.80	20.82	14.2 - 23.6	2.10
7	Co 87044 x Co 06002	69	6.56	1-14	2.85	19.82	14.2 - 24.2	1.96
8	Co 98010 x Co 0403	45	8.24	2-14	2.78	19.17	14.0 - 23.0	2.04
9	Co 06002 x Co 8347	55	8.29	1-20	3.52	21.01	17.6 - 24.8	1.65
10	Co 99006 x Co 06015	90	13.15	2-22	3.74	21.05	15.8 - 24.8	1.70
11	Co 94005 x Co 86011	41	8.87	3-16	2.73	21.05	17.0 - 24.0	1.81
12	Co 99006 x Co0403	30	9.63	5-16	2.93	20.65	15.4 - 23.4	1.79
13	Co 98010 x Co 0403	40	7.82	1-17	3.67	19.29	12.0 - 23.4	2.09
14	Co 0238 x Co 05009	20	7.83	4-17	3.41	18.75	14.6 - 22.2	1.95
15	Co 0320 x Co 99006	29	10.48	3-18	4.01	18.83	13.6 - 22.8	2.31
16	Co 0240 x Co 07010	30	8.86	1-17	3.52	19.99	14.2 - 22.8	2.01

3. RESULTS AND DISCUSSION

A family is worthwhile only if it includes superior individuals. Earlier studies [22,23] indicated that stable families could be easily identified through family selection which also offered the advantage for selection of traits with low heritability and identification of superior parents of the family. Hogarth et al. (1997) and Skinner (1971) reported that though satisfactory gains have been achieved using individual seedling selection, it was not very efficient and the identification of superior hybrid families and corresponding parents helped in increasing the individual selection efficiency.

In the current study, the maximum number progenies were selected from the cross combinations Co 99006 x Co 06015, Co 0403 x Co 0241, 2007-285 x Co 0209 and Co 94005 x Co 86011 with selectable progeny percentage of 63%, 32%, 30% and 28% respectively. The progenies from all crosses were pooled based on the common male and female parents in the combination and best male and female parents were identified based on the performance of the progenies for NMC (≥10) and H.R. Brix (≥20). The significance of parental lines performance was tested using 't' test assuming unequal variance. The clones Co 0241, Co 06015 and Co 8347 were identified as best male parents for sucrose content. The progenies derived from Co 0241 used as male parent recorded significantly higher sucrose content of 20.82% than the progenies from other male parents with 19.85%. Similarly, progenies obtained from Co 06015 (20.99%) and Co 8347 (20.81%) used as males recorded significantly higher sucrose percent of 20.99% and 20.81% respectively, in comparison with progenies derived other male parents of 19.65% and 19.79% of sucrose respectively. The clones Co 0209 and Co 05009 were negatively contributing to sucrose percent in their progenies when used as male parents by recording lower sucrose percent than the population (Table 2). The clones Co 0403, Co 06002 and Co 99006 were identified as best female parents for improving sucrose content. The seedlings obtained from Co 0403 have recorded 20.82% sucrose over the progenies of other female parents (19.87%). Similarly, the families derived from Co 06002 (20.81%) and Co 99006 (20.93%) recorded significantly superior for sucrose over other female parental crosses with sucrose of 19.81% and 19.36% respectively. The parental clones Co 0238, Co 07010 and Co 0320 were negatively associated with sucrose percent as their progenies recorded more sucrose than population (Table 3). With respect to another important trait, NMC, Co 0209, Co 06015 and Co 94008were regarded as best male parents. The progenies derived from these crosses recorded 14.23, 12.76 and 11.88 of NMC per clump, which is significantly higher than the population. Whereas families obtained from Co 05009, Co 06002 and Co 8347 were negatively correlated with the NMC. Among the female parents 2007-285, Co 07010 and Co 99006 were the best female parents for NMC, as their progenies recorded significantly higher number of canes than the population as a whole. However, the entries Co 87044, Co 06002 and Co 98010 were negatively correlated with NMC and their progenies accounted least number of canes in crosses where they involved. From the study it was concluded that the traits sucrose and NMC are inversely related with each other. A general trend was observed from the parental clones studied that increased positive response towards one trait has resulted in negative association with the other trait. So, the breeders need to balance the two traits while choosing the best cross combinations. In sugarcane populations, family selection was found to be successful in identifying families with a high proportion of individual and elite clone [14]. Gains of 3.4 and 5.3% from individual selection and gains of 9.7 and 12.91% from a combination of family and within-family selection—which was 2.5 times better than individual selection [24]. Individual clone selection in the ratoon and full-sib family selection using the BLUPIS procedure work well together to maximize resource utilization and produce new sugarcane cultivars [25]. These findings support those found by Pedrozo et al. (2011) through their investigation of environments and families. Family selection, which can also be used to estimate the breeding value of the parents that produced the progenies using Best Linear Unbiased Prediction (BLUP), to be an effective method for selecting seedlings [26]. A set of 450 clones were selected from the ground nursery, were further evaluated at fist clonal trails for identification best full sib families based on progeny performance derived from the 5 elite parental cross combination using Random coefficient model (27).

Table 2. Identification of best male parents based on family performance

Sl No.	Families	Family size	Non family size	NMC		HR Brix	
				Family mean	Population mean	Family mean	Population mean
1	Co 0209	55	767	14.23**	9.73**	19.10*	19.95*
2	Co 0241	25	797	10.36	10.08	20.82*	19.85*
3	Co 0403	115	707	8.46**	10.35**	19.60	19.92
4	Co 05009	20	802	7.55*	10.15*	18.90*	19.90*
5	Co 06002	69	753	6.53**	10.41**	19.82	19.85
6	Co 06015	139	683	12.76**	9.54**	20.99**	19.65**
7	Co 07010	50	772	10.66	10.05	19.64	19.89
8	Co 2010-03	70	752	8.00**	10.28**	19.67	19.89
9	Co 8347	70	752	8.55**	10.23**	20.81**	19.79**
10	Co 86011	105	717	9.67	10.15	19.85	19.90
11	Co 99006	29	793	10.48	10.07	18.83	19.94
12	Co 94008	75	747	11.88**	9.91**	18.94**	19.99**

Table 3. Identification of best female parents based on family performance

Sl No.	Families	Family size	Non family size	NMC		HR Brix	
				Family mean	Population mean	Family mean	Population mean
1	2007-285	40	782	11.40*	10.02*	19.00	19.90
2	2007-291	70	752	9.64	10.13	19.29*	19.95*
3	Co 0238	20	802	7.55*	10.15*	18.90*	19.92*
4	Co 0240	30	792	8.86*	10.13*	19.99	19.89
5	Co 0320	29	793	10.48	10.07	18.83*	19.94*
6	Co 0403	25	797	10.36	10.08	20.82*	19.87*
7	Co 06002	70	752	8.55**	10.23**	20.81**	19.81**
8	Co 07010	35	787	13.68**	9.93**	18.96**	19.94**
9	Co 87044	69	753	6.53**	10.41**	19.82	19.90
10	Co 94005	105	717	9.67	10.15	19.85	19.90
11	Co 94012	75	747	11.88**	9.91**	18.94**	19.99**
12	Co 98010	85	737	8.04**	10.32**	19.23**	19.97**
13	Co 99006	169	653	12.21**	9.54**	20.93**	19.63**

4. CONCLUSION

Sugarcane being a clonally propagated crop depends heavily on the hybridization process for the development of new clones/varieties which are suitable for cultivation under varied conditions. Hybridization/sexual reproduction is the faster, highly reliable and cost effective way of improvement for yield and quality in sugarcane crop. Successful hybridization/crossing depends on the choice of parents used, their ability to combine and pass on the positive traits to the progeny. In this context the present investigation involves 16 cross combinations with a population size of minimum of 20 seedlings were screened for quality (HR Brix) and cane yield (NMC) at 12 months' stage to identify a superior cross combination, which gives maximum number of selections based on the traits under consideration. the maximum number progenies were selected from the cross combinations Co 99006 x Co 06015, Co 0403 x Co 0241, 2007-285 x Co 0209 and Co 94005 x Co 86011 with selectable progeny percentage of 63%, 32%, 30% and 28% respectively. Based on the t-test performance of crosses combinations, the clones Co 0241, Co 06015 and Co 8347 used as male parents gave the superior progenies for quality with Co 0241 contributing higher selections with 20.82%. Similarly, progenies obtained from Co 06015 (20.99%) and Co 8347 (20.81%) used as males recorded significantly higher sucrose percent of 20.99% and 20.81% respectively. Performance of crosses plays an important role in deciding the parent's utility in the crossing programme and their ability to contribute superior traits to the next generation.

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