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Research Article

Combining ability for yield and quality in Sugarcane

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Abstract

Combining ability variances and effects were estimated for important yield and quality traits in sugarcane using line x tester mating design.Seven clones were used as females (lines) and three as males (testers). Five characters viz., number of millable canes, stalk diameter, stalk height, single cane weight and Brix % were considered in the present study. Twenty one crosses, obtained from seven lines x three testers were studied for sca, gca effects, *per-se* performance and heterosis. The study revealed no association between combining ability effect and heterotic response. Among the lines, Co 740, Co 86032 and Co 98010 and among the testers, Co 99006 was found to be good general combiner for agronomic characters. Four crosses viz., Co 86002 x Co 94008, Co 86032 x Co 99006, Co 98010 x Co 775 and Co 93020 x Co 99006 were promising for all the traits. Estimates of variance due to gca and sca and their ratio revealed predominantly non-additive gene action for these characters. Since sugarcane is a vegetatively propagated crop, heterosis can be fixed and exploited in F_1 generation. The crosses viz., Co 740 x Co 99006, Co 93020 x Co 94008, Co 8371 x Co 775, Co 86002 x Co 94008, Co 86032 x Co 99006 and Co 98010 x Co 99006 showed significant heterotic response for the traits under study. The present study rendered identification of new lines, testers and crosses for development of new varieties with improved yield and quality traits.

Key words : Combining ability, *gca, sca*

Introduction

Sugarcane is a member of the grass family and is classified in the genus *Saccharum*, tribe - Andropogoneae and family, Poaceae. The study of agronomic and commercial characters of interest in the progeny resulting from the crossings in sugarcane is of great importance. The accurate measurement of the progeny selection can be achieved through such studies. One such method used to select the parental material and identify their genetic worthiness for hybridization is Line x Tester analysis. This mating design provides information about the general and specific combining ability of parents and estimates of other genetic parameters. The mating plan involves "*l*" lines and "*t*" testers. All of these "l" lines are crossed to each of the "*t*" testers and thus, "l" x "*t*" full sib progenies are produced. These progenies resulting from line x tester matings, along with or without the parents, can be tested in a replicated trial using suitable field design (Comstock and Robinson1948; Singh and Chaudhary 1985). The present study was undertaken to estimate the variance components and effects due to general and specific combining ability in the progenies produced by line x tester crosses of selected clones.

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Material and methods

Seven lines viz., Co 740, Co 93020, Co 8371, Co 86002, Co 86032, CoC 671 and Co 98010 were crossed with three tester's viz., Co 775, Co 94008 and Co 99006 in an L X T mating design during 2007. Twenty one cross combinations along with their 10 parents and two standard checks viz., Co 86032 and CoC 671 were grown in a randomized block design with two replications during 2008 in Sugarcane Breeding Institute, Coimbatore. Both parents and F_1 were raised each in one row of 6m length with a spacing of 90 cm. The biometrical observations on the yield characters viz., number of millable canes, stalk diameter, stalk height, single cane weight and quality in terms of Brix % were recorded in 10 randomly selected plants from each of the two replications.The mean values of observations were subjected to LxT analysis (Comstock and Robinson1948; Singh and Chaudhary 1985) to estimate combining ability effects. Analysis of variance (ANOVA) was performed to test the significance of differences among the genotypes including crosses and parents.

Results and Discussion

Estimates of variance due to SCA and GCA and their ratios revealed that SCA were higher then GCA for the traits NMC, cane thickness and H.R brix % studied indicating a predominantly non-additive gene action for these characters. Three female parents viz., Co 8371, Co 98010 and CoC 671were identified as good combiners for number of millable canes which is the most important yield contributing factor. The parent Co 8371 contributed a large number of favourable genes for high cane yield and other related characters.Hence, the above female parents could be used in future programs for the improvement of the characters such as millable stalks, stalk thickness and stalk height. Three clones viz.,Co 740, Co 98010 and Co 86032 were identified as good combiners for cane thickness. Among the tester parents, Co 94008 and Co 775 contributed for NMC. The female parent CoC 671 and male parent Co 99006 were identified as good combiners for H.R brix %.The parents viz.,CoC 671, Co 740, Co 93020 and Co 86032 contributed for high quality progenies in combination with poor/good combiners for brix % and hence identified as good specific combiners for the trait. The higher GCA effects of female line CoC 671 and male tester Co 99006 for H.R brix indicate that both these parents maybe preferred for improving the trait through hybridization and selection programmes.

The SCA effects revealed that the crosses Co 86032 x Co 99006 and Co 86002 x Co 94008 could be better choice for all the traits under study. There was significant difference among the crosses for the yield and quality parameters. Two specific cross combinations Co 740 x Co 94008 and Co 86002 x Co 99006, were superior for yield parameters.Co 775 which was the best general combiner for brix, showed high SCA effect only in two cross combinations indicating that a parent having a good GCA effect need not necessarily produce better hybrids. The clone Co 98010 with poor GCA produced better hybrids for brix per cent. The crosses Co 740 x Co 775, Co 740 x Co 99006, Co 93020 x Co 94008, Coc 671 x Co 775 and Co 98010 x Co 99006 also appeared to be the best specific combiners for this trait. For number of millable stalks the best cross was Co 93020 x Co 99006 which were poor combiners for the trait. Female parents contributed more to the total variation of the character stalk diameter and both female and male parents contributed to brix % (Tables 1-3).

The parents viz.,CoC 671, Co 740, Co 93020,Co 86002, Co 86032 contributed for high quality progenies in combination with poor/good combiners for brix % and hence identified as good specific combiners for the trait.

Heterosis:

The cross Co 86032 x Co 99006 showed highest and significant relative heterosis and heterobeltiosis for all the three traits. Positive and significant relative heterosis and heterobeltiosis was observed for nmc in crosses Co 8371 x Co 99006, Co 8371 x Co 94008 and Co 98010 x Co 94008. Eight, ten and eighteen cross combinations showed positive relative heterosis and heterobetiosis for NMC,Cane diameter and H.R brix respectively (Table 4).

Based on gca, the parents Co 740, Co 86032, Co 94008 and Co 99006 could be better choices for improvement of yield and component traits through hybridization. The crosses Co 86002 x Co 94008, Co 86032 x Co 99006 Co 98010 x Co 775 and Co 93020 x Co 99006 with significant sca effects may be further exploited. Non additive gene action can be exploited in F_1 generation.

The information available for quantitative traits plays a vital role in planning for breeding strategies for a particular character(Hogarth, 1971). Chen *et al.* (1986) studied inheritance of quantitative characters in sugarcane and concluded that it is important for a breeder to evaluate parents before attempting hybridization programme. In the present study SCA (indicating non-additive genetic variance) has generally been greater than GCA for both cane parameters and sugar content. Similar results were obtained by Punia (1986), Hogarth *et al*., (1971 and 1981), Miller (1977), Rao and Ethirajan (1983) in sugarcane cross evaluation. The close relationship between per se performance and combining ability effect in the present study is due to predominance of additive x non additive gene action for yield components and additive x additive gene action for brix %. This situation invites for appropriate method of recurrent selection breeding after biparental mating and direct selection for brix per cent.

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Table 1.Mean squares from line x tester analysis for various characters

Source of Variation	DF	NMC	Cane dia (cm)	H.R brix %
Blocks	1	14.51	0.45	0.80
Parents	9	9.53	0.02	7.35
Males	2	16.67	0.01	1.64
Female	6	7.97	0.02	10.34
Male vs Female	1	4.61	0.03	0.84
Crosses	20	12.97	0.66	2.64
Parents vs. Crosses	1	2.01	0.49	55.55
Error	30	11.62	0.29	2.42
Total	**61**			

Table2. General combining ability effects of parents for various characters

Lines/Testers	HR brix	CD	NMC
Lines			
Co 740	-0.929	0.014	-0.119
Co 93020	0.555	-0.203	-2.119
Co 8371	-1.01	-0.236	1.714
Co 86002	-0.212	-0.086	-0.119
Co 86032	-0.545	0.551	-1.119
CoC 671	0.655	-0.22	0.381
Co 98010	-0.545	0.18	1.381
Testers			
Co 94008	-0.36	-0.135	0.214
Co 775	-0.038	-0.072	0.714
Co 99006	0.398	0.207	-0.929
SE	0.625	0.246	0.76

Table 3. Specific combining ability estimates

Specific crosses	HR brix	CD	NMC
Co740 x Co 94008	-1.957	-0.015	-0.881
Co 740 x Co 775	0.871	-0.178	2.619
Co 740 x Co 99006	1.086	0.193	-1.738
Co 93020 x Co 94008	0.360	0.501	-1.881
Co 93020 x Co 99006	-0.198	-0.44	3.262
Co 8371 x Co 775	-0.029	0.272	0.786
Co 8371 x Co 99006	0.036	-0.357	0.929
Co 86002 x Co 94008	2.026	0.235	0.119
Co 86002 x Co 775	-0.195	0.072	0.619
Co 86032 x Co 94008	-0.04	-0.54	-2.881
Co 86032 x Co 775	-0.362	-0.815	0.619
Co 86032 x Co 99006	0.402	1.356	2.262
CoC 671 x Co 94008	-0.24	0.068	3.619
CoC 671 x Co 775	0.338	-0.095	-0.881
CoC 671 x Co 99006	-0.098	*0.027*	-2.738
Co 98010 x Co 94008	-0.14	-0.332	3.619
Co 98010 x Co 775	-0.462	0.805	-2.381
Co 98010 x Co 99006	0.602	-0.473	-1.238
SE	**0.88**	**0.348**	**1.87**

Table 4 . Heterosis values of yield and quality parameters

Crosses	NMC		Cane diameter(cm)		H.R Brix %	
	Over Mid Parent	Over Better Parent	Over Mid Parent	Over Better Parent	Over Mid Parent	Over Better Parent
Co 740 x Co 775	12.195	9.524	-2.752	-5.357	15.430	9.887
Co 740 x Co 99006	-29.032	-45.000	23.364	17.857	15.517	6.915
Co 93020 x Co 94008	-30.769	-40.000	12.963	12.963	33.555	18.235
Co 93020 x Co 775	-38.889	-47.619	-4.673	-5.556	29.221	12.429
Co 93020 x Co 99006	30.769	13.333	-6.667	-9.259	27.273	7.979
Co 8371 x Co 94008	61.905	54.545	-3.704	-3.704	8.895	0.498
Co 8371 x Co 775	48.387	9.524	6.542	5.556	8.466	1.990
Co 8371 x Co 99006	90.476	81.818	-4.762	-7.407	7.969	4.478
Co 86002 x Co 94008	3.030	-22.727	6.422	5.455	17.647	12.299
Co 86002 x Co 775	-11.628	-13.636	3.704	1.818	4.945	2.139
Co 86002 x Co 99006	-21.212	-40.909	1.887	-1.818	-4.533	-4.787
Co 86032 x Co 94008	-28.000	-35.714	-0.450	-3.070	6.897	4.494
Co 86032 x Co 775	-2.857	-19.048	-7.273	-10.526	4.789	4.494
Co 86032 x Co 99006	36.000	21.429	85.185	75.439	8.197	5.319
CoC 671 x Co 94008	72.414	38.889	-4.587	-5.455	13.953	12.644
CoC 671 x Co 775	-12.821	-19.048	-7.407	-9.091	16.809	15.819
CoC 671 x Co 99006	-31.034	-44.444	9.434	5.455	13.260	9.043
Co 98010 x Co 94008	100.000	68.750	0.000	-3.704	3.933	-0.538
Co 98010 x Co 775	-13.514	-23.810	47.573	43.396	1.928	-0.538
Co 98010 x Co 99006	11.111	-6.250	10.891	9.804	-1.212	-4.118