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Combining Ability in Sugarcane

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General and specific combining ability variances and their effects were studied for 18 cross combinations in Line X Tester mating design. The study includes Cane yield and quality characters in sugarcane. Study indicated the predominance of non additive gene action for all the characters studied.Among the lines CoC 671 and Co 86032 were good general combiners for cane height, cane diameter, single cane weight, cane yield per plot, sugar yield per plot, CCS% at harvest, brix%, sucrose content and purity coefficient. *Erianthus procerus* was a good male donor for cane height, single cane weight, number of millable canes, and sugar yield per plot. Based on *sca* effects and mean performance three crosses, CoC 671 X *Erianthus procerus,* Co 86032 X *Erianthus procerus* and CoC 671 X *Saccharum spontaneum* were found promising for cane yield. The potential donor for brix could be selected on basis of gca effects of the female parent.

Key words: *Saccharum sp.* Complex, line x tester, Combining ability

Selection of suitable parents with high genetic potential is essential for developing sugarcane varieties with high cane and sugar yields. Evaluation of combining ability of geneotypes helps in identification of suitable parents for further exploitation. The general combining ability is based on additive gene action where as specific combinig ability is dependant on non additive type of gene action. Studies indicated that varieties good *in per se* performance, may not necessarily produce desirable progenies when used in hybridization. Hence, knowledge about combining ability of parents and on the performance of specific cross combinations become more important. In the present investigation combining ability of six genotypes with three different wild relatives of *Saccharum* have been studied for yield and quality characters.

Materials and Methods

The experimental material comprised of 18 sugarcane crosses, developed from six lines and three testers in a Line X Tester mating design. Three months old seedling were transplanted in randomized block design with four replications at the Sugar factory of E.I.D. Parry (India) Ltd., R&D farm, Nellikupam, Cuddalore during the month of March 2005. Each cross was represented by 5-10 clones.

The plot size was four rows of 5 meter length per clone in each replication. The rows were spaced 120 cm apart. Thirty two setts (two budded) were planted in each 5 meter row. Recommended cultural practice and need based plant protection measures were taken up. Data on 12 plants per replication were recorded for cane height, cane diameter, single cane weight, number of millable canes, cane yield per plot, sugar yield per plot, CCS%, brix percentage, purity coefficient and sucrose content. The combining ability analysis was carried out following Kempthrone (1957) and variances were estimated as per the method of Kempthrone and Curnow (1961). Additive (σ^2A) and dominance (σ^2 D), genetic variance components and their standard errors were computed following Hogarth (1977).

Results and Discussion

Analysis of variance indicated that there were significant differences among the crosses for number of cane height, number of millable canes,

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Table 1. Analysis of variance for combining ability and estimates of genetic componants in sugarcane

Source	DF	Cane height (cm)	Cane diameter (cm)	Single cane weight (kg)	NMC/ plot	Cane yield / plot(kg)	Sugar yield / plot(kg)	CCS (%)	Brix (%)	Sucrose (%)	Purity co-eficient
Replication	3	325.66**	0.06ns	0.09ns	111.92**	271.67**	5.88ns	0.13ns	0.20ns	0.24ns	0.97ns
Cross	17	7375.87**	0.68ns	0.53ns	167.17**	392.97**	8.00**	5.16**	7.18**	7.46**	12.46**
Line (c)	5	4345.48**	1.38ns	0.29ns	295.69**	396.50**	3.96ns	4.83ns	7.14ns	7.01ns	8.34**
Tester (c)	2	12168.00**	0.30ns	0.02ns	69.01**	' 93.46	6.11ns	1.34ns	2.88ns	2.41ns	1.95ns
Lines X Tester (c)	10	7932.63**	0.40ns	0.74ns	122.55**	*	10.39**	6.13**	8.06**	8.70ns	16.77**
GCA Variance		-12.5199	0.0063	-0.0049	1.0035	451.11**	-0.0538	-0.0218	-0.0198	-0.0278	-0.0949
SCA Variance		1961.1754	0.0940	0.1633	225.4711	68.4871	1.8393	1.4626	1.9578	2.0957	3.6304
σ^2 s /σ^2 g		-0.0064	0.0670	-0.0300	0.0045	-0.0191	-0.0293	-0.0149	-0.0101	-0.0133	-0.0261
Addiive variance		-50.0795	0.0251	-0.0196	4.0139	-5.2293	-0.2154	-0.0872	-0.0792	-0.1112	-0.3797
Dominance variance		7844.7014	0.3760	0.6533	101.8844	273.9482	7.3571	5.8505	7.8313	8.3827	14.5217
σ^2 A /σ^2 D		-0.0064	0.0668	-0.0300	0.0394	-0.0191	-0.0293	-0.0149	-0.0101	-0.0133	-0.0261

* Significant at 5 per cent level

* * Significant at 1 per cent level

cane yield, sugar yield, CCS%, brix%, sucrose% and purity coefficient (Table 1). The partitioning of variance due to crosses into its components revealed that there were differences among crosses due to lines (females) for cane height, number of millable canes, cane yield and purity coefficient. The differences due to testers (males) were also significant for number of millable canes, cane yield and cane height. The interaction between lines and testers was significant for cane height, number of millable canes, cane yield, sugar yield, and CCS%. This showed both general and specific combining ability variances were important for cane diameter and number of millable canes.

A perusal of estimates of combining ability variances revealed that specific combining ability variance was predominant for cane height, cane diameter, single cane weight, number of millable canes, cane yield, sugar yield and CCS%. These results were in agreement with those of Miller (1977) and Verma *et al* (1987).

The nature of genetic variance could be revealed by estimates of additive (σ^2A) and dominance (σ^2D) variance components, (Hogarth 1977). Relative importance of additive and dominance variances based on absolute quantities revealed that dominance variance was more important for all the characters studied.

GCA Effects

Among the lines CoC 671 recorded significant *gca* effects for cane height, cane diameter, single cane weight, cane yield per plot, CCS%, brix, sucrose content and

Table 2. General combining ability of parents for different characters in sugarcane

Parents **Lines**	Cane height (cm)	Cane diameter (cm)	Single cane weight (kg)	NMC/ plot	Cane yield / plot(kg)	Sugar yield / plot(kg)	CCS (%)	Brix (%)	Sucrose (%)	Purity co-eficient
PI 95-3295	-6.79 *	-0.18 **	-0.06 ns	2.31 ns	0.47 ns	-0.06 ns	-0.11 ns	-0.08 ns	-0.13 ns	-0.32 ns
Co 86-032	10.04 **	0.40 **	-0.25 **	5.81 **	1.64 ns	0.94 ns	0.85 **	1.14 **	0.67 **	0.05 ns
PI 98-3294	-28.79	0.50 **	-0.06 ns	4.56 **	-0.44 ns	-0.34 ns	-0.87 **	-0.89 **	-0.99 **	-1.46 **
PI 99-3299	2.88 ns	-0.12 **	0.09 ns	-3.86 **	-4.03 ns	-0.60 ns	-0.12 ns	-0.35 *	-0.24ns	0.33 ns
PI 00-3303	-5.54	0.05 ns	0.07 ns	-6.61 **	-7.28 ns	-0.35 ns	-0.36 *	-0.52 **	-0.43 *	0.45 ns
CoC 67-1	28.21 **	0.35 **	0.20 *	-2.19 ns	9.64 *	0.42 ns	0.61 **	0.70 **	1.11 **	0.96 *
Testers										
Narenga	-1.00 ns	-0.12 **	0.02 ns	1.85 *	-2.28 ns	-0.58 ns	-0.25 *	-0.40 **	-0.37 **	-0.14 ns
Erianthus procerus	23.00 **	0.02 ns	0.01 ns	-0.36 ns	1.10 ns	0.25 ns	0.13 ns	0.25 *	0.19 ns	-0.19 ns
S.spontaneum L.	-22.00 **	0.10 **	-0.03 ns	-1.49 ns	1.18 ns	0.33 ns	0.12 ns	0.14 ns	0.18 ns	0.33 ns

* Significant at 5 per cent level * * Significant at 1 per cent level

Table 3. Mean of parents

Parents **Lines**	Cane height (cm)	Cane diameter (cm)	Single cane weight (kg)	NMC/ plot	Cane yield / plot(kg)	Sugar yield / plot(kg)	CCS (%)	Brix (%)	Sucrose (%)	Purity co-eficient
PI 95-3295	146.25	2.55	0.75	32.50	24.25	3.29	13.56	22.62	19.37	85.65
Co 86-032	242.50	2.80	2.43	55.50	146.25	20.17	13.79	20.45	18.68	87.18
PI 98-3294	167.50	2.78	0.61	39.75	24.00	2.94	12.23	21.41	18.30	86.87
PI 99-3299	193.50	2.60	2.32	55.50	135.00	17.27	12.79	21.43	17.49	85.50
PI 00-3303	217.50	3.77	2.31	60.25	139.25	17.02	12.22	19.72	17.27	85.45
CoC 67-1	280.25	2.88	2.50	63.00	137.75	18.17	13.19	22.52	19.57	87.62
Testers										
Narenga	64.50	0.35	0.18	618.75	110.50	0.19	0.17	5.99	2.24	37.39
Erianthus procerus	395.00	1.82	0.36	572.00	208.25	0.33	0.16	6.19	2.30	37.13
S.spontaneum L.	99.25	0.70	0.19	705.25	134.25	0.21	0.16	5.55	2.08	37.59

Table 4. Specific combining ability of crosses

No	L X T	Crosses	Cane height (cm)	Cane diameter (cm)	Single cane weight (kgs)	NMC / plot	Cane yield / plot (kgs)	Sugar yield / plot (kgs)	CCS %	Brix %	Sucrose %	Purity co-eficient
1	L1XT1	PI 95-3295 x *Narenga*	-24.50 **	0.01 ns	0.73 **	‘-9.35 *	4.24 ns	0.77 ns	-0.39 ns	-0.27ns	-0.42ns	-1.17 ns
2	L2XT1	Co 86-032 x *Narenga*	-1.17 ns	0.04 ns	-0.17 ns	1.28 ns	-3.10 ns	-1.35 ns	-1.40 **	-1.53**	-1.64 **	-2.15 **
3	L3XT1	PI 98-3294 x *Narenga*	-36.67 **	-0.05 ns	-0.56 **	1.51 ns	-10.18 ns	-2.02 *	-0.70 **	-1.06 **	-0.89 **	0.06 ns
4	L4XT1	PI 99-3299 x *Narenga*	14.67 **	-0.28 **	0.17 ns	-3.35 ns	6.57 ns	0.74 ns	-0.26ns	-0.48 *	-0.35ns	0.34 ns
5	L5XT1	PI 00-3303 x *Narenga*	-22.58 **	-0.07 ns	-0.01 ns	0.03 ns	-0.26 ns	-1.67 *	-1.20 **	-1.03 **	-1.30 **	-2.58 **
6	L6XT1	CoC 67-1 x *Narenga*	7.92 ns	-0.29 **	-0.31 *	3.32 ns	-10.35 ns	0.97 ns	-1.23 **	1.51 **	1.34 **	1.11 ns
7	L1XT2	PI 95-3295 x *Erianthus*	3.33 ns	-0.23 **	-0.44 **	5.40 ns	-12.39 *	0.60 ns	1.25 **	-1.60 **	-1.56 **	-1.36 *
8	L2XT2	Co 86-032 x *Erianthus*	44.33 **	0.35 **	0.32 *	-3.72 ns	6.99 ns	0.55 ns	1.46 **	1.60 **	1.59 **	1.53 *
9	L3XT2	PI 98-3294 x *Erianthus*	-47.67 **	-0.30 **	0.11 ns	-1.68 ns	5.40 ns	-1.16 ns	-0.02ns	-0.00ns	-0.03ns	-0.18 ns
10	L4XT2	PI 99-3299 x *Erianthus*	34.75 **	0.05 ns	‘ -0.30 *	-1.57 ns	-10.97 ns	0.11 ns	0.96 **	1.28 **	1.15 **	0.47 ns
11	L5XT2	PI 00-3303 x *Erianthus*	-10.25 *	0.18 **	0.13 ns	-0.06 ns	4.40 ns	1.24 ns	0.45ns	0.25ns	0.49ns	1.68 *
12	L6XT2	CoC 67-1 x *Erianthus*	58.08 **	0.58 **	0.32 *	8.07 *	10.61 ns	1.25 ns	1.09 **	1.34 **	1.31 **	2.17 **
13	L1XT3	PI 95-3295 x *S. spontaneum L.*	-28.42 **	-0.02 ns	-0.19 ns	5.32 ns	5.53 ns	0.20 ns	-0.32ns	-0.73 **	-0.47ns	0.79 ns
14	L2XT3	Co 86-032 x *S. spontaneum L.*	-14.42 **	0.01 ns	-0.27 *	1.44 ns	-9.85 ns	-0.09 ns	0.77 **	0.76 **	0.90 **	1.36 *
15	L3XT3	PI 98-3294 x *S. spontaneum L.*	37.83 **	0.00 ns	0.13 ns	-6.76 ns	4.32 ns	-0.11 ns	-0.45ns	-0.03ns	-0.43ns	-2.15**
16	L4XT3	PI 99-3299 x *S. spontaneum L.*	42.83 **	-0.35 **	-0.12 ns	0.40 ns	-6.06 ns	-2.43 **	-1.24 **	-1.40**	-1.50 **	-1.95 **
17	L5XT3	PI 00-3303 x *S. spontaneum L.*	4.08 ns	0.13 *	-0.00 ns	1.03 ns	1.82 ns	0.42 ns	0.13ns	0.28ns	0.16ns	-0.22 ns
18	L6XT3	CoC 67-1 x *S. spontaneum L.*	62.17 **	0.22 **	0.46 **	-1.43 ns	13.28 *	2.01 *	1.11 **	1.12 **	1.65 **	2.24 **

Table 5. Means of crosses

No	L X T	Crosses	Cane height (cm)	Cane diameter (cm)	Single cane weight (kgs)	NMC / plot	Cane yield / plot (kgs)	Sugar yield / plot (kgs)	CCS %	Brix %	Sucrose %	Purity co-eficient
1	L1XT1	PI 95-3295 x *Narenga*	234.00	2.20	2.85	45.75	146.75	13.69	9.33	16.69	13.65	81.78
2	L2XT1	Co 86-032 x *Narenga*	230.50	2.15	2.46	57.50	141.50	12.45	8.80	15.71	12.87	81.91
3	L3XT1	PI 98-3294 x *Narenga*	240.00	1.92	2.03	50.75	134.50	12.74	9.47	16.44	13.72	83.48
4	L4XT1	PI 99-3299 x *Narenga*	242.00	1.60	2.77	55.25	153.00	14.19	9.28	16.05	13.42	83.66
5	L5XT1	PI 00-3303 x *Narenga*	183.75	1.72	2.44	59.75	145.50	12.85	8.83	16.14	13.02	80.69
6	L6XT1	CoC 67-1 x *Narenga*	259.25	2.00	2.10	65.25	135.50	11.18	8.25	15.20	12.20	80.40
7	L1XT2	PI 95-3295 x *Erianthus*	199.00	2.40	2.20	62.75	138.00	14.09	10.21	17.76	14.80	83.34
8	L2XT2	Co 86-032 x *Erianthus*	285.75	2.72	2.95	54.75	160.75	18.00	11.20	18.57	15.97	86.03
9	L3XT2	PI 98-3294 x *Erianthus*	172.00	2.25	2.70	59.00	148.00	13.91	9.40	16.70	13.72	82.10
10	L4XT2	PI 99-3299 x *Erianthus*	269.25	2.30	2.50	50.50	125.75	13.17	10.47	17.98	15.11	84.07
11	L5XT2	PI 00-3303 x *Erianthus*	203.25	2.35	2.91	50.00	144.50	15.13	10.47	17.60	15.00	85.22
12	L6XT2	CoC 67-1 x *Erianthus*	290.50	2.77	3.31	66.50	154.50	17.06	11.04	18.95	15.93	84.01
13	L1XT3	PI 95-3295 x *S. spontaneum L.*	190.50	2.40	2.72	51.50	139.00	14.38	10.35	17.45	14.84	85.02
14	L2XT3	Co 86-032 x *S. spontaneum L.*	183.50	2.35	2.62	48.75	127.00	14.89	11.72	19.59	16.76	85.54
15	L3XT3	PI 98-3294 x *S. spontaneum L.*	219.00	2.20	3.31	42.75	141.25	14.96	10.59	18.69	15.43	82.55
16	L4XT3	PI 99-3299 x *S. spontaneum L.*	155.50	2.38	2.66	51.00	134.25	12.26	9.13	16.35	13.37	81.77
17	L5XT3	PI 00-3303 x *S. spontaneum L.*	200.75	1.80	2.76	52.75	145.50	15.66	10.77	18.68	15.59	83.45
18	L6XT3	CoC 67-1 x *S. spontaneum L.*	299.75	3.35	3.37	52.50	159.25	18.75	11.78	19.41	16.76	86.35

Table 6. Best crosses based on sca effects and per se performance in sugarcane

No	Character	*sca* effect	per se performance
1	Cane height (cm)	CoC 67-1 x *S. spontaneum L.*	CoC 67-1 x *S. spontaneum L.*
2	Cane diameter (cm)	CoC 67-1 x *Erianthus*	CoC 67-1 x *S. spontaneum L.*
3	Single cane weight (kgs)	PI 95-3295 x *Narenga*	CoC 67-1 x *S. spontaneum L.*
4	NMC per plot	CoC 67-1 x *Erianthus*	CoC 67-1 x *Erianthus*
5	Cane yield per plot (kgs)	CoC 67-1 x *S. spontaneum L.*	Co 86-032 x *Erianthus*
6	Sugar yield per plot (kgs)	CoC 67-1 x *S. spontaneum L.*	CoC 67-1 x *S. spontaneum L.*
7	CCS %	Co 86-032 x *Erianthus*	CoC 67-1 x *S. spontaneum L.*
8	Brix %	Co 86-032 x *Erianthus*	Co 86-032 x S. spontaneum L.
9	Sucrose %	CoC 67-1 x *Narenga*	CoC 67-1 x *S. spontaneum L.*
10	Purity co-efficient	CoC 67-1 x *S. spontaneum L.*	CoC 67-1 x *S. spontaneum L.*

purity coefficient .The Line Co 86032 recorded signicficant *gca* effects for cane height, cane diameter, number of millable canes, CCS%, brix and sucrose content and higher gca effects for cane yield, sugar yield, and purity coefficient (Table 2 and 3).

Among the testers *Saccharum spontaneum* had significant *gca* effects for cane diameter where as *Erianthus procerus* had significant gca effects for cane height.

SCA Effects

The perusal of specific combining ability effects and means of cross progenies for different characters revealed that the cross CoC 671 X *Saccharum spontaneum* was the most promising for cane yield. This cross also recorded significant *sca* and high mean of cane height, cane diameter, single cane weight, sugar yield per plot, CCS%, sucrose content and purity coefficient. The cross CoC 671 X *Erianthus procerus* recorded significant *sca* and high mean for cane height, cane diameter, single cane weight, number of millable canes, cane yield, sugar yield, CCS%, brix%, sucrose content and purity coefficient. The cross Co 86032 X *Erianthus procerus* was also promising for cane height, cane diameter, single cane weight, cane yield per plot and CCS%. The cross involving CoC 671 as female parent had high mean and significant *sca* for most of the characters studied which included cane yield and brix%. This parent also recorded significant *gca* effects including cane yield, its component characters and brix. Thus, it is observed that CoC 671 was the promising female donor for brix and cane yield. These results were in agreement with the findings of Loh and Tseng (1950) who reported that sucrose content in the progeny was largely dependant on female or seed parent. The results suggested that the potential donor for cane yield and brix%, might be selected on the basis of *gca* effects of female parents.

From the above results it was obvious that *Erianthus procerus* was the good male donor for cane yield and most of the yield component characters studied. The progenies of the crosses

CoC 671 X *Erianthus procerus,* CoC 671 X *Saccharum spontaneum* and Co 86032 X *Erianthus procerus* were promising for cane yield.

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