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Combining Ability Effects for Juice Yield and its Contributing Traits in Sweet Sorghum [*Sorghum bicolor* (L.) moench]

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ABSTRACT: Research investigation was carried out with 45 new hybrids of sweet sorghum developed by crossing 3 male sterile lines with 15 restorers in L × T mating design and were grown in randomized block design (RBD) with three replications during Kharif-2019. Parents RSSV-355, RSSV-512, RSSV-454 and RSSV-498 were observed as good general combiners for juice yield and its contributing traits. Among the lines, CMS-1409 has been observed best general combiner for juice yield and its contributing traits. Out of 45 hybrids, 14 hybrids recorded significant positive SCA effects, among which, cross combinations CMS-1409 × RSSV-499, CMS-185A × RSV-350 and CMS-185A × RSV- 498 exhibited high sca effects for juice yield, with high SCA effects for its contributing characters. Based on per se performance, GCA effects of parents, SCA effects of hybrids and heterotic performance for yield, the cross combinations *viz*., CMS-1409 × RSSV-512, ICMS-479 × RSSV-355 and CMS-1409 × RSSV-499, CMS-1409 × RSSV-498 and CMS-1409 × RSSV-355 appeared to be the most promising.

Keywords: Combining ability, Sweet Sorghum, Juice yield, SCA effects.

INTRODUCTION

Sweet sorghum [*Sorghum bicolor* (L.) Moench] is a very special-purpose sorghum with a sugar-rich stalk, similar to sugarcane. Besides having vigorous growth, high sugar accumulation, and high biomass production capacity, sweet sorghum has wider adaptability (Reddy and Sanjana 2003). Given that water availability is poised to become a major constraint to agricultural production in the coming years (Rayan and Spencer 2001), cultivation of sugarcane becomes difficult. Sweet sorghum would be a good crop option instead of sugarcane in such situations Sweet sorghum can be grown with less irrigation and rainfall and purchased less inputs compared to sugarcane. The sugar concentration in the juice extracted from sweet sorghum ranges from 16-23 per cent Brix. It has a great potential value for jaggery, syrup and most importantly fuel alcohol production (Ratanavathi *et al*., 2004). The silage after extraction of juice from sweet sorghum can be used for co-generation of power. Combining ability analysis gives the information for the selection of the desirable parents and cross combinations for exploitation. In this analysis, total genetic variation is partitioned into GCA and SCA effects to verify the parents in terms of combining ability to combine in hybrid combinations.

If GCA variances are found to be higher than SCA variances, then there is a preponderance of additive gene action and in this case, progeny selection will be effective for the genetic improvement of such traits, If SCA variances are found to be higher than GCA variances then there is a preponderance of non-additive gene action and therefore heterosis breeding may be rewarding, but if both GCA and SCA variances are of equal magnitude it shows that both additive and non-additive gene action is equally important in the expression of characters. The present study was carried out to assess the general and specific combing ability effects for juice yield and its contributing traits in 45 hybrids with their 18 parents and one check (CSH-22).

MATERIAL AND METHODS

The present investigation was carried out at Botany Farm, Post Graduate Institute, M.P.K.V., Rahuri, during the period *Kharif* - 2019. The experimental material consisting of 64 genotypes (45 hybrids, 15 restorer lines, 3 maintainers (B) lines and one check) was laid out in randomized block design (RBD) with three replications. Each entry was sown in two rows of 4 m length in each replication. The inter and intra-row spacing was 60 cm and 15 cm, respectively. The F1's, lines, testers and check were separately randomized within the replications. Half of the recommended dose of nitrogen along with the entire dose of phosphorus and potassium were applied at the time of sowing. The remaining 50 per cent of the nitrogen was top-dressed at 35 days after sowing. The crop stood well and the crop growth was satisfactorily observed. All the recommended practices were followed for growing a successful crop. Observations were recorded on randomly selected 5 competitive plants in each replication in respective 13 characters *viz*., days to 50 % Flowering, days to physiological maturity, nodes/plant stem girth (diameter) (cm), plant height (cm), cane weight (t/ha), juice yield (lit/ha), total biomass yield (t/ha),

reducing sugar (%), non-reducing sugar(%), total sugar (%), brix (%), ethanol yield (lit/ha). The mean values of these five plants were used for combining ability analysis as per the method suggested by Kempthorne (1957); Arunachalam (1974) using INDOSTAT-Statistical software.

RESULT AND DISCUSSION

It was found that the mean squares due to lines, testers as well as lines vs tester interaction and hybrids were observed significant for all the characters under studies, except the magnitude of variance in lines and hybrids was found non-significant for stem girth. The estimates of GCA and SCA variance were found significant for all the characters under study, however, the estimates of SCA variance were found non-significant for nodes/plant and stem girth.

Significant variance indicated the presence of a substantial amount of genetic variability among the parents and crosses for respective characters. The analysis of variance for combining ability indicated that general and specific combining ability variances were significant for all the characters studied, except stem girth. This suggested that both additive and non-additive gene effects were involved in the genetic control of juice yield and its contributing traits. In the present investigation highly significant differences were obtained for *gca* effects for all the thirteen traits studied, it was found that the parent CMS-1409A was a good general combiner for ten traits, including, juice yield and most of its contributing traits *i.e*. plant height (cm), nodes/plant, stem girth (cm), total biomass yield (t/ha), cane weight (t/ha) and total sugar per cent. Among all 18 parents, none of the parents expressed significant *gca* effects for all the thirteen traits studied. Line CMS-1409A and testers, RSSV-512, RSSV-355 and RSSV-499 also have good *per se* performance for most of the characters indicating scope for their exploitation in future breeding programmes to isolate desirable transgressive segregants for juice yield and its components. The results in the present investigation are the findings reported by various workers, Indubala (2010) Vinaykumar *et al.* (2011); Umakantha *et al.* (2012); Bahadure *et al*. (2015); Kumar *et al*. (2017); Soujanya *et al*. (2018); Ingle *et al*. (2018).

Sprague and Tatum (1942) reported that the specific combining ability effects and heterosis can be regarded as arising primarily from non-additive genetic effects, which are non-fixable. In the present investigation, Three types of parental combinations were observed in the crosses. However, the majority of the crosses exhibited high sca effects as a result of either high x low or low x high or high x high GCA parents indicating a genetic interaction of the additive x dominance or dominance x additive or dominance x dominance interactions.

The cross combinations *viz;* CMS-1409 × RSSV-512, ICMS-479 × RSSV-355 and CMS-1409 × RSSV-499 exhibited high mean performance and were found promising with significant SCA effects for more number of characters with high GCA × high GCA or low GCA × high GCA or high GCA × low GCA type combinations, which indicated additive, dominance and additive x additive gene effects were predominant in the expression of respective traits which also indicating synergy amongst parents. Therefore, due to the possibility of fixation of the gene, single plant selection could be practised in segregating generations to isolate superior lines from such combinations. This suggested that information on *gca* effects should be supplemented by SCA effects of cross combination to predict the transgressive types possibly be available in segregating generations. Selection is rapid if the GCA effects of the parents and SCA effects of the crosses are in the same direction.

The *per se* performance, GCA effects of parents, SCA effects of hybrids and heterotic performance for yield and its principal components in the F1 hybrids the cross combinations *viz*; CMS-1409 x RSSV-512, ICMS-479 x RSSV-355 and CMS-1409 x RSSV-499, CMS-1409 x RSSV-498 and CMS-1409 x RSSV-355 appeared to be the most promising (Table 5). Hence the desired size of the F2 population of these crosses can be grown to superior transgressive segregants that may be obtained from these four crosses and they may be utilized in further breeding programmes. The promising crosses showing high mean performance, a high magnitude of useful heterosis with high SCA effects and involving good general combiner could be successfully exploited for hybrid vigour.

The Promising heterotic crosses involving one parent with good GCA and another with poor or even negative *gca* effects may give desirable transgressive segregants which will help in the development of varieties and inbred lines. Further crosses involving good × good general combining parent with high SCA effect can be handled by simple varietal improvement programme for respective characters. Similar situations were also observed by Chand *et al*. (2005); Indubala (2010); Vinaykumar *et al.* (2011), Umakantha *et al.* (2012), Bahadure *et al*. (2015); Kumar *et al*. (2017); Soujanya *et al*. (2018); Ingle *et al*. (2018).

Table 1: Analysis of variance for combining ability and estimates of gca and sca variances in sweet sorghum.

Sources	DF	Days to 50 % flowering	Days to maturity	Nodes/ plant	Plant height (cm)	Stem girth (diameter) (cm)	Total biomass yield (t/ha)	Cane weight (t/ha)
Replication	**2**	6.096	3.17	2.54	61.76	0.213	22.97	9.28
Treatments	**62**	128.64**	103.83**	4.52*	14183.50**	0.814**	48152**	358.77**
Parents	**17**	185.85**	154.10**	9.56**	30025.61**	1.59**	132.09**	73.13**
Line	**2**	3.11	330.17*	0.77	1008.77**	0.0025	66.33**	28.23**
Testers	**14**	197.11**	33.44**	2.35*	7850.18**	1.65**	81.63**	59.67**
Line vs. Tester	**1**	393.61**	171.11**	128.13**	398515.29**	3.84**	969.91**	351.41**
Parent vs. hybrid	**1**	434.30**	200.77**	25.14**	83853.39**	0.015	3502.98**	2195.88**
Hybrids	**44**	99.59**	82.21**	2.10*	6479.28**	0.53	547.86**	427.38**
Error	**124**	1.67	2.09	1.20	20.40	0.43	9.93	2.99
Estimates								
σ^2_{gca}		12.14**	17.36**	0.16**	932.1**	0.04**	113.5**	81.24**
σ^2_{sca}		17.07**	8.54**	-0.07	1189.9**	-0.02	54.19**	50.16**
σ^2_A		24.28	34.72	0.32	18.64.3	0.08	227.16	162.4
σ^2_D		17.07	8.54	-0.07	1189.9	-0.02	54.19	50.16
σ^2_A/var $_D$		1.42	4.06	-4.24	1.56	-3.25	4.19	3.23

Table 2: General combining ability effects of parents for juice yield and its contributing traits in sweet sorghum.

Sr. No.	Parents	Days to 50 % flower	Days to maturity	Nodes/ plant	Plant height (cm)	Stem girth (diameter) (cm)	Total biomass yield (t/ha)	Cane weight (t/ha)
	Females	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	CMS-185 A	-3.393**	-4.200**	-0.430**	-8.185**	-0.176**	-0.593**	-1.417**
2	ICMS- 479A	-0.059**	-0.333**	0.037	-26.141**	-0.104*	-10.82**	-8.820**
3	CMS-1409 A	3.452	4.533*	0.393**	34.326**	0.277**	11.41**	9.957**
	SE ±	0.19	0.21	0.16	0.67	0.098	0.46	0.25
	Males							
4	RSSV-454	2.430 **	2.467 **	0.415	33.948 **	0.287*	6.696**	6.182**
5	RSSV-498	-1.904**	0.022	0.748 **	9.393 **	0.210*	3.763**	7.444**
6	RSSV-499	-3.681**	-2.422 **	-0.252	-46.385 **	-0.279**	3.370**	1.342*
7	RSSV-500	-2.126**	-1.644 **	-0.474*	-16.719 **	-0.258**	-7.644**	-5.543**
8	RSSV-502	-4.904**	-4.422 **	-1.141 **	-12.052 **	-0.175*	-4.893 **	-4.544**
9	RSSV-503	-3.348 **	-2.089 **	-1.030 **	-30.607 **	-0.334**	-7.274 **	-5.702**
10	RSSV-483	0.096	0.022	-0.363	17.163 **	-0.089**	-8.269 **	-7.468**
11	RSSV-453	0.319	0.8	-0.141	6.059 **	-0.039	-7.481 **	-5.847**
12	RSSV-417	-0.348 **	-1.756 **	-0.141	-4.052 **	-0.069	-6.833 **	-6.556**
13	RSSV-512	7.763 **	2.467 **	0.637*	39.504**	0.310**	17.977 **	14.007**
14	RSSV-350	8.430 **	8.022 **	0.970 **	37.170 **	0.325**	0.801	1.759**
15	RSSV-397	0.874 *	1.911 **	-0.03	-1.496	-0.028	1.633	-2.114**
16	RSSV-430	-0.015 **	-0.311	-0.252	-37.496 **	-0.244**	-4.624 **	-3.939**
17	RSSV-387	-0.459 **	-0.311	0.415	2.393	-0.064	-0.583	-3.164**
18	RSSV-355	-3.126 **	-2.756 **	0.637*	37.504 **	0.448 **	13.361 **	14.144**
	SE(gi) ±	**0.43**	**0.48**	**0.36**	**1.5**	**0.22**	**1.05**	**0.57**

Note : * Significant at 5% level of significance, ** Significant at 1% level of significance

Table 2: Contd…

Sr. No.	Parents	Juice yield (lit/ha)	Brix (%)	Reducing sugar (%)	Total sugar (%)	Non- reducing sugar	Ethanol yield (lit/ha)
	Females	**8**	**9**	**10**	**11**	**12**	**13**
1	CMS-185 A	-896.31**	-0.563**	0.161**	-0.034**	-0.202**	-63.27**
2	ICMS- 479A	-1251.17**	1.226**	-0.195**	-0.712**	-0.530**	-97.919 **
3	CMS-1409 A	2147.48**	-0.663**	0.034**	0.746**	0.732**	161.193 **
	SE ±	139.01	0.12	0.026	0.1	0.1	7.88
	Males						
4	RSSV-454	2191.51**	-0.163**	-0.104**	-0.745 **	-0.665 **	78.504 **
5	RSSV-498	902.95**	0.393**	-0.159 **	0.399	0.548 *	43.948 *
6	RSSV-499	-1773.71**	-0.941 **	-0.126 **	-0.912 **	-0.812 **	-130.496 **
7	RSSV-500	-498.37**	0.059	-0.148 *	-0.367	-0.224	-46.719 **
8	RSSV-502	-2039.71**	-0.163**	0.207 **	0.633 **	0.492 *	-89.719 **
9	RSSV-503	-1533.15**	-1.219 **	0.074**	0.544 *	0.452	-69.385 **
10	RSSV-483	-1359.04**	0.115	-0.104**	0.199	0.362	-81.607 **
11	RSSV-453	-774.37**	-0.052**	-0.104**	-0.334	-0.238	-61.274 **
12	RSSV-417	-316.26**	-0.385**	0.285 **	0.844 **	0.537 *	6.948
13	RSSV-512	3665.40**	1.726 **	0.419 **	1.266 **	0.864**	288.170 **
14	RSSV-350	90.51**	-0.830 **	0.041**	0.11	0.063	60.059 **
15	RSSV-397	-653.37**	1.281 **	-0.237 **	-0.623 **	-0.429	-78.274 **
16	RSSV-430	-1149.60**	0.726 *	-0.126 *	-0.790 **	-0.656 **	-87.163 **
17	RSSV-387	-1380.93**	-0.385**	0.085**	-0.267	-0.329	-57.607 **
18	RSSV-355	3810.17**	-0.163**	-0.004**	0.044	0.035	224.615 **
	SE(gi) ±	**310.84**	**0.28**	**0.058**	**0.23**	**0.23**	**17.63**

Note : * Significant at 5% level of significance, ** Significant at 1% level of significance

Table 3: Specific combining ability (sca) effects for juice yield and its contributing traits in 45 crosses of sweet sorghum.

Sr. No.	Crosses	Days to 50 % flower	Days to maturity	Nodes/ plant	Plant Height (cm)	Stem girth (diameter) (cm)	Total biomass yield (t/ha)	Cane weight (t/ha)
		1	2	3	4	5	6	7
1	CMS-185 x RSSV- 454	-0.83	1.08	-0.34	6.40*	0.20	0.29	2.02*
2	CMS-185 x RSSV- 498	-0.49	-2.13*	0.31	31.96 **	0.27	3.53	1.49
3	CMS-185 x RSSV- 499	1.28	0.64	0.65	-28.92**	-0.132	-11.03**	-3.65 **
4	CMS-185 x RSSV- 500	3.05**	3.53**	0.20	25.74**	0.227	6.37**	8.26**
5	CMS-185 x RSSV- 502	1.504 *	1.644	-1.126	19.074 **	-0.406	5.953 **	4.91**
6	CMS-185 x RSSV- 503	1.281	1.644	-0.570	17.963 **	-0.007	2.778	2.089 *
7	CMS-185 x RSSV- 483	-4.496 **	-3.800 **	-0.237	8.852 **	0.095	1.462	-3.101 **
8	CMS-185 x RSSV- 453	-0.719	0.422	-0.459	-15.370 **	-0.375	-7.956 **	-3.726 **
9	CMS-185 x RSSV- 417	1.281	2.311 **	0.541	31.741 **	0.542	3.363	1.113
10	CMS-185 x RSSV- 512	6.504 **	2.089 *	0.096	4.519	0.196	6.307 **	3.006 **
11	CMS-185 x RSSV- 350	-3.830 **	-4.800 **	0.430	0.852	0.147	6.372 **	6.747 **
12	CMS-185 x RSSV- 397	1.059	-0.689	0.096	-26.481 **	-0.296	-6.850**	-3.333 **
13	CMS-185 x RSSV- 430	-3.385 **	0.200	-0.681	-70.815 **	-0.397	-1.289	-5.374 **
14	CMS-185 x RSSV-386	-3.607 **	-2.467 **	0.652	24.696 **	-0.077	-2.000	-2.976 **
15	CMS-185 x RSSV- 355	1.393	0.311	0.430	-34.415 **	0.007	-7.301 **	-7.590 **
16	ICMS-479 x RSSV- 454	-0.496	-0.444	0.185	-18.637 **	0.057	9.591 **	7.427 **
17	ICMS-479 x RSSV-498	-4.496 **	-0.333	-0.148	-8.304 **	-0.389	-10.07 **	-10.17 **
18	ICMS-479 x RSSV- 499	1.281	1.444	-0.148	-28.970 **	-0.290	0.793	-9.536 **
19	ICMS-479 x RSSV- 500	-3.274 **	-3.000 **	0.074	-54.415 **	-0.324	-3.626 *	5.275 **
20	ICMS-479 x RSSV- 502	-1.496 *	-3.556 **	1.074	-40.526 **	0.172	-8.270 **	-2.821 **
21	ICMS-479 x RSSV- 503	-1.385	-0.556	0.296	31.585 **	-0.366	-4.996 **	-4.470 **
22	ICMS-479 x RSSV- 483	-0.83	1.333	-0.370	11.030 **	-0.250	-5.451 **	-1.713
23	ICMS-479 x RSSV- 453	0.281	1.222	0.074	14.141 **	0.417	12.64 **	7.849 **
24	ICMS-479 x RSSV- 417	-0.385	0.111	-0.259	19.141 **	0.067	5.120 **	5.398 **
25	ICMS-479 x RSSV- 512	5.504 **	5.222 **	0.296	13.807 **	0.084	-3.827 *	-4.662 **
26	ICMS-479 x RSSV- 350	5.83**	3.33**	-0.370	19.141**	0.156	-6.958**	-5.001**
27	ICMS-479 x RSSV- 397	2.059 **	-0.556	-0.704	13.919 **	0.256	9.763 **	2.539 *
28	ICMS-479 x RSSV- 430	0.948	-0.667	0.185	28.141 **	0.061	-2.423	3.088 **
29	ICMS-479 x RSSV-386	-1.941 *	-1.667 *	-0.481	1.2	0.001	4.080 *	3.799 **
30	ICMS-479 x RSSV- 355	-1.607 *	-1.889 *	0.296	1.37	0.349	3.609	2.998 **
31	CMS-1409 x RSSV- 45	1.326	-0.644	0.163	-31.10 **	-0.262	-9.882 **	-9.449 **
32	CMS-1409 x RSSV-498	4.993 **	2.467 **	-0.170	2.452	0.119	6.514 **	8.679 **
33	CMS-1409 x RSSV- 499	-2.563 **	-2.089 *	-0.504	47.563 **	0.422	10.241 **	13.101 **
34	CMS-1409 x RSSV- 500	0.215	-0.533	-0.281	-17.43 **	0.097	-2.745	-13.538 **
35	CMS-1409 x RSSV- 502	-0.007	1.911 *	0.052	9.896 **	0.234	2.317	-2.110 *
36	CMS-1409 x RSSV- 503	0.104	-1.089	0.274	36.452 **	0.373	2.218	2.381 *
37	CMS-1409 x RSSV- 483	5.326 **	2.467 **	0.607	31.674 **	0.155	3.989 *	4.814 **
38	CMS-1409 x RSSV- 453	0.437	-1.644	0.385	-16.25 **	-0.042	-4.688 *	-4.123 **
39	CMS-1409 x RSSV- 417	-0.896	-2.42 **	-0.281	-42.70 **	-0.608	-8.483 **	-6.511 **
40	CMS-1409 x RSSV- 512	-12.07 **	-7.31 **	-0.393	-18.69 **	-0.281	-2.479	1.655
41	CMS-1409 x RSSV- 350	-2.007 **	1.467	-0.059	-19.93 **	-0.303	0.586	-1.747
42	CMS-1409 x RSSV- 397	-3.119 **	1.244	0.607	12.674 **	0.040	-2.913	0.793
43	CMS-1409 x RSSV- 430	2.437 **	0.467	0.496	42.007 **	0.336	3.712 *	2.285 *
44	CMS-1409 x RSSV-386	5.548 **	4.133 **	-0.170	-4.881	0.076	-2.079	-0.823
45	CMS-1409 x RSSV- 355	0.215	1.578	-0.726	-31.659 **	-0.356	3.693 *	4.592 **
SE (Sij) ±		0.74	0.83	0.63	2.6	0.38	1.81	0.99
	C.D.5%	1.48	1.660	1.260	5.18	0.760	3.61	1.98
	C.D.1%	1.96	2.190	1.660	6.68	1.000	4.79	2.63

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table 4: Specific combining ability (sca) effects for juice yield and its contributing traits in 45 crosses of *sweet* sorghum.

Sr. No.	Crosses	Juice yield (lit/ha)	Brix (%)	Reducing sugar (%)	Total sugar (%)	Non reducing sugar (%)	Ethanol yield (lit/ha)
		8	9	10	11	12	13
1	CMS-185 x RSSV- 454	1403.089 *	0.007	-0.272 **	-1.577 **	-1.324 **	-1.059
2	CMS-185 x RSSV- 498	1927.311**	-0.215	-0.283 **	-0.088	0.176	69.830 *
3	CMS-185 x RSSV- 499	101.644	0.452	-0.116	-1.544 **	-1.418 **	-25.393
4	CMS-185 x RSSV- 500	1859.644 **	-0.881	0.106	-0.155	-0.265	106.830 **
5	CMS-185 x RSSV- 502	-2212.355 **	-0.659	0.150	-0.221	-0.198	-134.170 **
6	CMS-185 x RSSV- 503	801.089	0.063	-0.016	1.667 **	1.686 **	105.830 **
7	CMS-185 x RSSV- 483	-755.022	0.396	0.295 **	1.779 **	1.432 **	19.052
8	CMS-185 x RSSV- 453	-1267.689 *	-0.104	0.061	-0.055	-0.114	-55.615
9	CMS-185 x RSSV- 417	-125.467	0.563	0.339 **	1.234 **	0.920 *	46.163
10	CMS-185 x RSSV- 512	118.867	-0.881	0.573 **	1.412 **	0.814 *	76.274 *
11	CMS-185 x RSSV- 350	1887.089 **	1.007 *	-0.016	0.634	0.658	143.719 **
12	CMS-185 x RSSV- 397	-1038.689	1.563 **	0.028	1.601 **	1.524 **	16.052
13	CMS-185 x RSSV- 430	-1523.467 **	-0.548	0.050	-0.066	-0.090	-76.059 *

14	CMS-185 x RSSV-386	62.867	0.896	-0.327 **	-1.555 **	-1.313 **	-64.281 *
15	CMS-185 x RSSV- 355	1238.91*	-1.659 **	-0.572 **	-3.066 **	-2.488 **	-227.170 **
16	ICMS-479 x RSSV- 454	731.289	-0.448	0.317 **	0.234	-0.060	47.25
17	ICMS-479 x RSSV-498	-2348.822 **	-0.004	0.173	0.456	0.293	-100.193 **
18	ICMS-479 x RSSV- 499	-2367.489 **	-0.670	0.139	1.401 **	1.260 **	-86.081 **
19	ICMS-479 x RSSV- 500	374.511	0.330	0.228 *	0.456	0.256	43.807
20	ICMS-479 x RSSV- 502	592.178	0.219	-0.161	-0.177	-0.087	22.141
21	ICMS-479 x RSSV- 503	-1931.711 **	0.941	0.139	-0.588	-0.710	-117.193 **
22	ICMS-479 x RSSV- 483	-213.489	-0.226	0.184	0.223	-0.057	8.696
23	ICMS-479 x RSSV- 453	1642.511 **	1.774 **	0.484 **	1.723 **	1.267 **	162.696 **
24	ICMS-479 x RSSV- 417	1952.400 **	-1.226 *	-0.205 *	-1.255 **	-1.046 *	60.807 *
25	ICMS-479 x RSSV- 512	-1570.933 **	-0.337	-0.439 **	-1.310 **	-0.879 *	-181.415 **
26	ICMS-479 x RSSV-350	-796.044	0.885	0.039	-0.888 *	-0.914 *	-84.304 **
27	ICMS-479 x RSSV- 397	702.844	-2.226 **	-0.083	0.679	0.808 *	80.696 **
28	ICMS-479 x RSSV- 430	745.733	0.663	-0.427 **	-1.021 *	-0.589	5.585
29	ICMS-479 x RSSV-386	-744.6	-0.226	-0.505 **	-1.044 *	-0.549	-87.304 **
30	ICMS-479 x RSSV- 355	3231.622 **	0.552	0.117	1.112 **	1.007 *	224.807 **
31	CMS-1409 x RSSV- 454	-2134.378 **	0.441	-0.045	1.343 **	1.384 **	30.363
32	CMS-1409 x RSSV-498	421.511	0.219	0.110	-0.368	-0.469	111.474 **
33	CMS-1409 x RSSV- 499	2265.844 **	0.219	-0.023	0.143	0.158	-150.637 **
34	CMS-1409 x RSSV- 500	-2234.156 **	0.552	-0.334 **	-0.301	0.010	112.030 **
35	CMS-1409 x RSSV- 502	1620.178 **	0.441	0.010	0.399	0.284	11.363
36	CMS-1409 x RSSV- 503	1130.622 *	-1.004 *	-0.123	-1.079 **	-0.976 *	-27.748
37	CMS-1409 x RSSV- 483	968.511	-0.170	-0.479 **	-2.001 **	-1.376 **	-107.082 **
38	CMS-1409 x RSSV- 453	-374.822	-1.670 **	-0.545 **	-1.668 **	-1.152 **	-106.970 **
39	CMS-1409 x RSSV- 417	-1826.933 **	0.663	-0.134	0.021	0.125	105.141**
40	CMS-1409 x RSSV- 512	1452.067 **	1.219 *	-0.134	-0.101	0.065	-59.415
41	CMS-1409 x RSSV- 350	-1091.044 *	-1.893 **	-0.023	0.254	0.256	-96.748 **
42	CMS-1409 x RSSV- 397	335.845	0.663	0.055	-2.279 **	-2.331 **	70.474 *
43	CMS-1409 x RSSV- 430	777.733	-0.115	0.377 **	1.087 **	0.679	151.585**
44	CMS-1409 x RSSV-386	681.733	-0.670	0.833 **	2.599 **	1.862 **	2.363
45	CMS-1409 x RSSV- 355	-1992.711 **	1.107 *	0.455 **	1.954 **	1.481 **	4.88
SE (Sij) ±		**538.39**	**0.49**	**0.1**	**0.4**	**0.39**	**30.54**
	C.D.5%	**1069**	**0.980**	**0.200**	**0.8**	**0.790**	**60.69**
	C.D.1%	**1417**	**1.300**	**0.260**	**1.06**	**1.040**	**80.4**

Note : * Significant at 5% level of significance, ** Significant at 1% level of significance

Table 5: Mean juice yield performance, gca and sca effects in promising crosses.

Crosses	Mean Juice yield(lit/ha)	sca effect	Mean Ethanol yield (lit/ha)	gca effects of parents for juice yield	Significant gca effects of parents for other characters
CMS-1409 x RSSV-512	**15067**	**1452****	998	2147.48* * x 3665.2 ** H H	P_1- 3,4.5,6.7,8,11,12, P_2 - 3, 4, 5, 6, 7, 8, 9,11,12
ICMS-479 x RSSV-355	**13592**	**3231****	795	-1251.1** x 3810.1 ** L H	P_1 - 1,2,9,10 P_2 - 1, 2,3, 4, 5, 6, 7, 8,10,12
CMS-1409 x RSSV-355	**11767**	**1992****	831	2147.48* * x 3810.1 ** H H	P_1 - 3,4.5,6.7,8,11,12, P_2 - 1, 2,3, 4, 5, 6, 7, 8,10,12
CMS-1409 x RSSV-498	**11274**	**421***	679	2147.48* * x 902.9 ** H H	P_1 - 3,4.5,6.7,8,11,12, P_2 -1, 3, 4,5,6, 7, 8, 9,10,12
CMS-1409 x RSSV-499	**10441**	**2265****	585	2147.48* * x -1773.7 ** H L	P_1 - 3,4.5,6.7,8,11,12, P_2 -1, 2, 6, 7, 10

Note : * Significant at 5% level of significance, ** Note : * Significant at 5% level of significance, ** Significant at 1% level of significance
H - High gca effect, P_1- Line, P_2- Tester
L - Low gca effect, **1**) Days to 50% Flowering, **2)** days to Maturity, **3**) Nodes/plant, **4)** Plant height, **5)** Stem girth **6**) Total biomass yield **7)** Cane weight, **8**) Juice yield, **9)** Brix %, **10**) Reducing sugar %, **11)** Total sugar, **12)** Ethanol yield.

CONCLUSIONS

The parents RSSV-355, RSSV-512, RSSV-454 and RSSV-498, were observed good general combiners for juice yield and its contributing traits. Among the lines, CMS-1409 has been observed best general combiner for juice yield and most of its contributing traits.

Out of 45 hybrids, 14 hybrids recorded significant positive sca effects, among which, cross CMS-1409 x RSSV-499 (high x low), CMS-185A x RSV-350 (low x high) and CMS-185A x RSV-498 (low x high) combinations exhibited high sca effects for juice yield with high sca effects for juice yield contributing characters.

FUTURE SCOPE

Among the parents CMS-1409, RSSV-355, RSSV-512, RSSV-454 and RSSV-498 were found to be the best general combiners for juice yield and most of the juice yield contributing traits, thus these parents should be included in future hybridization programmes for improvement in juice yield along with total biomass yield in sweet sorghum.

Based on mean performance and sca effects of crosses, five crosses *viz.*, CMS-1409 x RSSV-512, ICMS-479 x RSSV-355 and CMS-1409 x RSSV-499 CMS-1409 x RSSV-498 and CMS-1409 x RSSV-355 are identified as promising crosses. These crosses need further evaluation in preliminary or multilocations hybrid trials for further commercial exploitation.

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Conflicts of Interest. None.

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