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Research Article

Combining ability of parents and hybrids for juice yield and its attributing traits in sweet sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract:
An investigation was carried out to assess the combining ability and nature of gene action in respect of juice yield and its attributing traits in 72 new hybrids of sweet sorghum developed by crossing 4 male sterile lines with 18 testers in Line × Tester mating design and grown in Randomized Block Design with two replications during *kharif 2008.* The variance among the lines in respect of their general combining ability was highly significant for days to 50 per cent flowering, nodes per plant and juice yield, where as variance among testers was significant for juice yield. The variance due to line × tester interaction was significant for all the characters indicating differential response of lines with different testers. SCA variance was relatively higher in magnitude for all the traits indicating predominance of non-additive gene action in the genetic control of these traits. ICSA 38 and ICSA 102 among the lines and ICSV 93046, E 36-1, ICSV 700, SEREDO and GD 65008 among the testers, were identified as good general combiners indicating their ability in transmitting additive genes in the desirable direction to their progenies. Highly significant *sca* effects were observed in most of the hybrids for all the characters studied and good specific combiners for different characters involved parents with high × high, high × low, low × high and low × low general combinations.

Key words: Combining ability, sweet sorghum, juice yield.
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Introduction

Sweet sorghum [*Sorghum bicolor* (L.) Moench] is similar to grain sorghum with a sugar-rich stalk, almost like sugarcane. The sugar content varies from 16-23% Brix. Besides having wide adaptability, rapid growth, high sugar accumulation and biomass production potential, it has great potential for jaggery, syrup and biofuel (ethanol) production and the grains from sweet sorghum can be used for food or feed. The recent policy of Indian Government for blending of alcohol in petrol to an extent of five per cent increased the demand for alternative and commercially feasible raw material like sweet sorghum for ethanol production which emerged as a supplementary crop to sugarcane in rainfed areas of the country (Reddy and Sanjana Reddy, 2003). In any plant breeding programme, combining ability provides necessary information on nature and magnitude of gene action involved which helps for selection of parents for breeding programme. The line × tester mating design helps in assessing the combining ability of parents there by selection of superior parents as well as cross combinations (Sprague and Tatum, 1942). Accordingly, the present study was carried out to assess the nature of combining ability and gene action in respect of juice yield and its attributing traits in 72 hybrids and their 22 parents of sweet sorghum.

Material and Methods

The experimental material used in the present investigation comprised of 72 new hybrids developed by using 4 male sterile lines with 18 testers through line × tester mating design and their 22 parents (4 B lines and 18 testers) which were grown in Randomized Block Design with two replications during *kharif* 2008 at Zonal Agricultural Research Station, University of Agricultural Sciences, Ghandhi Krishi Vigyana Kendra, Bengaluru. Each entry was raised in single row of 3 m length with a spacing of 45 cm × 15 cm. All the package of practices were followed to raise a good and healthy crop. Observations were recorded on five randomly tagged plants in each entry in respect of nine characters *viz*., days to 50 per cent flowering, stem girth (cm), nodes per plant, cane height (cm), cane weight (g/plant), mean internodal length (cm), juice extraction per cent, juice volume (ml/plant) and juice yield (g/plant). The mean values of these five plants were used for combining ability analysis as per the method suggested by Kempthorne (1957) and Arunachalam (1974) using “TNAUSTAT-Statistical package”.

Results and Discussion

The variance among the lines was highly significant for days to 50 per cent flowering, nodes per plant and juice yield, where as variance among testers were significant for juice yield. However, the variance due to line × tester interaction was significant for all the characters indicating interaction of different lines with different testers. It is evident from the study that, SCA variances were higher in magnitude compared to GCA variances for all the characters indicating predominance of non-additive gene action in the genetic control of these characters and good scope for heterosis breeding (Table I).

Estimates of *gca* effects indicated that, none of the parents was a good general combiner for all the traits studied. However, the line ICSA 38 was a good general combiner for nodes per plant, mean internodal length, cane height, juice extraction per cent and juice yield, whereas ICSA 102 was good general combiner for days to 50 per cent flowering, juice volume and juice yield (Table II). Among the testers, ICSV 93046 was good general combiners for stem girth, cane weight, juice volume, juice extraction per cent and juice yield. Whereas, E 36-1 was next best tester with desirable significant *gca* effects for stem girth, cane height, juice volume, juice extraction per cent and juice yield. The tester ICSV 700 had significant desirable *gca* effects for days to 50 per cent flowering, stem girth, mean internodal length, juice volume and juice yield. SEREDO and GD 65008 were the next best testers with desirable significant *gca* effects for three characters each. The results imply that two lines and five testers were good general combiners indicating their ability in transmitting additive genes in the desirable direction to their progenies and hence these superior parents can be utilized for production of superior genotypes in segregating populations by concentration of desirable genes with additive effect.

The cross combinations *viz*.,‘ICSA 264 × ICSV 96143’, ‘ICSA 102 × ICSV 96143’, ‘ICSA 84 × GD 65008’ and ‘ICSA 102 × ICSRV 93046’ for days to 50 per cent flowering; ‘ICSA 102 × SPV 1411’, ‘ICSA 38 × GD 65008’, ‘ICSA 102 × ICSR 56’ and ‘ICSA 264 × ICSV 700’ for stem girth; ‘ICSA 84 × SPV 1359’, ‘ICSA 264 × ICSR 160’, ‘ICSA 102 × SPV 1411’ and ‘ICSA 264 × ICSV 96143’ for nodes per plant; ‘ICSA 38 × NTJ 2’, ‘ICSA 84 × SPV 1359’, ‘ICSA 264 × ICSR 160’ and ‘ICSA 102 × SPV 1411’ for cane height; ‘ICSA 38 × GD 65008’, ‘ICSA 84 × SPV 1359’, ‘ICSA 102 × E 36-1’ and ‘ICSA 38 × ICSV 25263’ for cane weight; ‘ICSA 264 × E 36-1’, ‘ICSA 84 × NTJ 2’, ‘ICSA 102 × NTJ 2’ and ‘ICSA 264 × ICSV 96143’ for mean internodal length; ‘ICSA 102 × E 36-1’, ‘ICSA 102 × ICSV 700’, ‘ICSA 264 × SEREDO’ and ‘ICSA 84 × ICSV 25263’ for juice volume; ‘ICSA 38 × ICSV 96143’, ‘ICSA 84 × ICSV 25263’, ‘ICSA 84 × ICSR 196’ and ‘ICSA 264 × ICSR 160’ for juice extraction per cent and ‘ICSA 38 × GD 65008’, ‘ICSA 102 × ICSR E 36-1’, ‘ICSA 264 × ICSR 160’ and ‘ICSA 84 × SPV 1359’ for juice yield were good specific combiners (Table III), as indicated by the *per se* performance and *sca* effects. Hence, these crosses can be utilized for heterosis breeding. Similar studies were reported by Selvi and Palanisamy (1990), Nguyen *et al*. (1997), Laxman (2001), Biradar *et al.* (2004) for identification of good cross combinations.

In general, maximum crosses showing significant *sca* effects were invariably associated with better *per se* performance for respective traits (Table III). The good specific combiners for different characters involved parents with high × high, high × low, low × high and low × low general combinations.

In majority of the cases, the crosses exhibiting high *sca* effects were found to have both or one of the parents as good general combiner for the characters studied revealing non-additive gene action in the genetic control which was in accordance with the results of Jagadeshwar and Shinde (1992) and Kadam *et al*. (2000).

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Table 1. **Analysis of variance for line × tester for nine characters in sweet sorghum**

Source of Variation	df	Mean Sum of Squares								
		Days to 50 % flowering	Stem girth (cm)	Nodes per plant	Mean internodal length (cm)	Cane height (cm)	Cane weight (g/plant)	Juice extraction per cent	Juice volume (ml/plant)	Juice yield (g/plant)
Lines	17	86.64**	0.0855	3.99**	22.67	1632.80	16444.35	583.08	6139.19	6448.00**
Testers	3	36.35	0.5410	6.85	51.60	10408.33	37666.32	890.01	3466.13	3361.78**
Line × Testers	51	41.41**	0.1283**	4.00**	21.16**	2409.43**	27781.38**	179.89**	5822.45**	7512.04**
Error	93	2.88	0.0064	0.26	0.54	63.28	401.96	47.71	330.68	199.86
GCA Variance		0.1540	0.0001	0.0020	0.1260	2.2110	33.4120	0.7650	0.3450	6.2580
SCA Variance		24.63	0.12	2.32	25.00	2355.59	13545.68	320.80	2369.35	2787.62

** Significant at one per cent probability level

Table 2. **Estimates of general combining ability effects of parents for nine characters in sweet sorghum**

Parents	Days to 50 per cent flowering	Stem girth (cm)	Nodes per plant	Mean internodal length(cm)	Cane height (cm)	Cane weight (g/plant)	Juice volume (ml/plant)	Juice extraction per cent	Juice yield (g/plant)
Lines									
ICSB 38	1.48 **	0.02	0.61 **	1.24 **	25.14 **	-6.06	0.60	4.80 **	6.10 *
ICSB 84	-0.27	0.14**	-0.10	1.05 *	-9.03 **	40.99 **	-4.09	-4.25 **	-7.30 **
ICSB 102	-0.74 *	-0.01s	-0.43 **	-0.61	-4.58 **	0.68	13.27 **	-6.06 **	10.32**
ICSB 264	-0.47	-0.15 **	-0.08	-1.68 **	-11.53 **	-37.61**	-9.78 **	5.50 **	-9.12**
S.Em ±	0.3	0.01	0.08	0.4	1.42	3.45	3.35	0.75	2.58
CD at 5%	0.84	0.03	0.24	1.14	3.99	9.66	9.40	2.12	7.23
CD at 1%	1.12	0.04	0.32	1.52	5.30	12.83	12.49	2.82	9.60
Testers									
E 36-1	2.91 **	0.26 **	-0.53 *	1.52	9.65 **	7.69	43.23 **	11.07 **	27.67 **
GD 65008	1.53 *	-0.12 **	-0.52 *	0.22	3.40	119.28 **	-6.82	4.04 *	49.93**
ICSR 160	3.16 **	-0.13 **	0.98 **	-2.88 **	12.78 **	7.89*	-8.67	-10.41 **	-13.42*
ICSR 196	1.41 *	0.14 **	-0.24	-1.42	-24.72 **	-49.40**	-1.90	7.02 **	-15.95 **
ICSR 56	2.66 **	-0.09 **	0.28	-0.88	17.15 **	0.82	-59.97 **	12.82 **	-44.50 **
ICSR 91005	2.53 **	-0.13 **	-1.29 **	1.77 *	-39.72 **	2.82	-5.08	-5.18 **	-6.64
ICSR 93034	2.91 **	-0.06 *	-0.64 **	3.72 **	-11.60 **	-3.09	-21.12 **	-9.49 **	-22.01 **
ICSV 111	-0.72	-0.09 **	0.88 **	1.74 *	7.65 *	5.13	21.54 **	-0.18	-0.12
ICSV 25263	-2.59 **	0.11 **	0.03	-0.98	-9.10 **	29.16 **	2.23	-5.80 **	0.52
ICSV 574	1.41 *	-0.07 *	-0.27	1.58	2.15	-3.89	-15.65 *	0.60	-5.97
ICSV 700	-2.97 **	0.11 **	-0.74 **	2.12 *	-7.22 *	-20.53 **	14.37 *	-8.64 **	19.14 **
ICSV 91005	-3.72 **	-0.14 **	-0.13	-0.16	-0.97	13.57	-26.33 **	1.74	0.89
ICSV 93046	1.78 **	0.06 *	-0.04	0.27	1.53	38.04 **	53.29 **	7.26 **	50.47 **
ICSV 96143	6.03 **	0.03	0.41 *	-3.31 **	-12.85 **	-110.50 **	-47.08 **	1.45	-30.39**
NTJ 2	-4.22 **	0.12 **	0.48 **	-0.67	10.97 **	20.86 **	20.67 **	-8.51 **	-6.91
SEREDO	-3.84 **	0.08 **	-0.54 *	0.27	7.15 *	-31.04 **	-4.36	2.31	26.58 **
SPV 1359	-3.47 **	-0.09 **	2.06 **	-3.06 **	-4.10	-7.87	-12.27	-0.59	-16.03 **
SPV 1411	-4.84 **	0.11 **	-0.14	0.17	37.78 **	-17.62 *	-6.68	0.47	-12.83 *
S.Em.±	0.64	0.02	0.18	0.86	3.02	7.32	7.12	1.61	5.48
CD at 5%	1.79	0.07	0.52	2.42	8.47	20.50	19.95	4.50	15.34
CD at 1%	2.38	0.10	0.69	3.22	11.25	27.22	26.50	5.98	20.38

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

Table 3. Best specific combinations (crosses), their *per se* performance and *sca* effects and *gca* status of their parents for different characters

Character	Cross	*Per se* performance	*sca* effects	*gca* status of parents
Days to 50 % Flowering	ICSA 264 × ICSV 96143	57.0	-9.03 **	L × L
	ICSA 102 × ICSV 96143	61.0	-8.76 **	L × L
	ICSA 84 × GD 65008	63.0	-7.23 **	H × H
	ICSA 102 × ICSV 93046	58.0	-6.51 **	L × H
Stem girth (cm)	ICSA 102 × SPV 1411	2.42	0.42 **	L × H
	ICSA 38 × GD 65008	2.61	0.30 **	H × H
	ICSA 102 × ICSR 56	1.87	0.38 **	L × L
	ICSA 264 × ICSV 700	2.20	0.35 **	L × H
Nodes per plant	ICSA 84 × SPV 1359	8.10	2.46 **	H × L
	ICSA 264 × ICSR 160	8.20	2.40 **	L × H
	ICSA 102 × SPV 1411	5.40	2.34 **	L × H
	ICSA 264 × ICSV 96143	6.90	2.28 **	L × L
Cane height (cm)	ICSA 38 × NTJ 2	210.00	48.36 **	H × H
	ICSA 84 × SPV 1359	220.00	47.78 **	H × L
	ICSA 264 × ICSR 160	225.00	46.28 **	L × H
	ICSA 102 × SPV 1411	112.50	42.71 **	L × H
Cane weight (g/plant)	ICSA 38 × GD 65008	315.88	326.03 **	H × H
	ICSA 84 × SPV 1359	448.00	237.95 **	H × L
	ICSA 102 × E 36-1	417.50	202.58 **	L × H
	ICSA 38 × ICSV 25263	243.17	183.15 **	H × H
Mean internodal length (cm)	ICSA 264 × E 36-1	20.40	5.40 **	L × H
	ICSA 38×NTJ 2	26.05	5.15 **	H × H
	ICSA 102 × NTJ 2	27.19	4.54 **	L × H
	ICSA 264 × ICSV 96143	21.40	4.38 **	L × L
Juice volume (ml/plant)	ICSA 102 × E 36-1	215.00	49.54 **	L × H
	ICSA 102 × ICSV 700	201.30	49.10 **	L × H
	ICSA 264×SEREDO	205.00	46.68 **	L × H
	ICSA 84 × ICSV 252563	113.30	45.26 **	H × H
Juice extraction (%)	ICSA 38 × ICSV 96143	62.71	21.77 **	H × L
	ICSA 84 × ICSV 25263	56.68	22.42 **	H × H
	ICSA 84 × ICSR 196	54.74	21.05 **	H × H
	ICSA 264 × ICSR 160	60.70	20.44 **	L × H
Juice yield (g/plant)	ICSA 38 ×GD 65008	204.00	56.43 **	H × H
	ICSA 102 × E 36-1	220.23	54.81 **	L × H
	ICSA 264×ICSR 160	130.50	53.59 **	L × H
	ICSA 84 × SPV 1359	175.38	53.13 **	H × L