RESEARCH PAPER

Asian Journal of Bio Science Vol. 6 Issue 2 (Oct., 2011) : 223-226

Studies on combining ability for bio-energy traits in sweet sorghum [*Sorghum bicolor* (L.) Moench]

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(**Received:** Jul., 2011; **Revised:** Aug., 2011; **Accepted :** Sep., 2011)

An investigation was carried out to assess the nature of combining ability and gene action in respect of bio-energy traits in 72 new hybrids of sweet sorghum developed by crossing 4 male sterile lines and 18 testers in line × tester mating design and grown in Randomized Block Design with two replications during *Kharif* 2008 at 'K' Block of Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. The variance among the lines (for juice yield and total sugars), testers (for juice yield) and line × tester interaction (for all the characters studied) in respect of their general combining ability were highly significant indicating predominance of non-additive gene action in genetic control of these traits. ICSA 84, ICSA 38 and ICSA 264 among the lines and NTJ 2, E 36-1 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 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 : *Sweet sorghum, Bio-energy traits, Combining ability*

Vinay Kumar, R., Jagadeesh, B.N., Talekar, Sidramappa and Gururaja Rao, M. R. (2011). Studies on combining ability for bio-energy traits in sweet sorghum [*Sorghum bicolor* (L.) Moench]. *Asian J. Bio. Sci.*, **6** (2) : 223-226.

INTRODUCTION

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 bio-energy traits in 72 hybrids and their 22 parents of sweet sorghum [*Sorghum bicolor* (L.) Moench] supplied by Directorate of Sorghum Research and ICRISAT, Hyderabad.

RESEARCH METHODOLOGY

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 'K' Block of Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. Each entry was raised in single row of 3m length following recommended spacing of 45cm × 15cm. All the package of practices were followed to raise a good and healthy crop. Observations were recorded on five randomly selected tagged plants in each entry in respect of seven characters *viz*., cane weight, Brix per cent, juice yield, reducing sugars, total sugars, ethanol yield and grain yield. The mean values of these five plants were used for combining ability analysis as per the method suggested by the earlier workers (Kempthorne, 1957 and Arunachalam, 1974).

RESULTS AND ANALYSIS

The variance among the lines was significant for juice yield and total sugars, whereas the variance among the testers was significant for juice yield. However, the variance due to line × tester interaction was highly 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

Table 1 : Analysis of variance for line × tester for seven characters in sweet sorghum

Sources of variation	df	Mean sum of squares						
		Cane weight (g/plant)	Brix per cent	Juice yield (g/plant)	Reducing sugars (per cent)	Total sugars (per cent)	Grain yield (g/plant)	Ethanol yield (ml/plant)
Lines	17	16444.35	12.78	6448.00**	5.55	10.15**	316.07	2.59
Testers	3	37666.32	2.91	3361.78**	6.713	5.32	1188.15	2.78
Line × Testers	51	27781.38**	24.95**	7512.04**	3.64**	13.75**	317.03**	2.76**
Error	93	401.96	0.60	199.86	0.032	0.12	105.70	2.12
Variance of GCA		33.412	0.023	6.258	0.001	0.072	0.336	0.009
Variance of SCA		13545.68	6.34	2787.62	0.042	4.88	161.35	1.49

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 1).

Estimates of *gca* effects indicated that, none of the parents was a good general combiner for all the traits studied. However, the line ICSA 84 was a good general combiner for cane weight (g/plant) and total sugars (%), whereas ICSA 38 was good general combiner for juice yield and grain yield. The line ICSA 264 was the next best general combiner with desirable significant *gca* effects for Brix per cent and total sugars (Table 2). Among

Table 2 : Estimates of general combining ability effects for seven characters in sweet sorghum

Parentrs	Cane weight (g/plant)	Brix per cent	Juice yield (g/plant)	Reducing sugars (per cent)	Total sugars (per cent)	Grain yield (g/plant)	Ethanol yield (ml/plant)
Lines							
ICSB 38	-6.06	-0.04	6.10 *	-0.01	-0.09	7.48 **	0.49
ICSB 84	40.99 **	0.04	-7.30 **	-0.05	0.38 **	1.33	0.18
ICSB 102	0.68	-0.35 **	10.32**	0.04	-0.50 **	-5.51 **	-0.15
ICSB 264	-37.61**	0.34 *	-9.12**	0.03	0.20 **	-3.30 *	-0.52 *
S.Em ±	3.45	0.13	2.58	0.02	0.05	2.07	0.24
CD at 5%	9.66	0.36	7.23	0.08	0.14	5.80	0.69
CD at 1%	12.83	0.48	9.60	0.10	0.18	7.71	0.91
Testers							
E 36-1	7.69	1.09 **	27.67 **	0.26 **	0.87 **	-3.13	1.24 *
GD 65008	119.28 **	0.93 **	49.93**	-0.11*	1.03 **	-8.50	-1.03
ICSR 160	7.89*	0.04	-13.42*	-0.10	0.40 **	-7.59 *	-1.13 *
ICSR 196	-49.40**	0.07	-15.95 **	-0.12 *	0.22 *	7.74 *	-0.67
ICSR 56	0.82	0.98 **	-44.50 **	-0.05	-1.07 **	7.81 *	-1.02 *
ICSR91005	2.82	-1.53 **	-6.64	-0.24 **	-1.23 **	-8.09	1.02 *
ICSR93034	-3.09	0.19	-22.01 **	-0.15 *	-0.84 **	10.25 **	-0.84
ICSV 111	5.13	-0.81 **	-0.12	0.01	0.79 **	3.53	0.08
ICSV25263	29.16 **	-0.55	0.52	-0.08	-0.26 *	-5.60	0.81
ICSV 574	-3.89	0.23	-5.97	-0.03	0.21 *	-6.44	0.56
ICSV 700	-20.53 **	-1.66 **	19.14 **	0.04	-1.01 **	-6.81	-0.92
ICSV91005	13.57	0.14	0.89	0.10	0.03	-10.56 **	1.73 **
ICSV93046	38.04 **	-0.05	50.47 **	-0.14 *	0.07	9.88 **	0.27
ICSV96143	-110.50 **	-2.15 **	-30.39**	-0.13 *	-1.44 **	12.52 **	-0.93
NTJ 2	20.86 **	0.88 **	-6.91	0.23 **	0.52 **	8.94 *	1.14 *
SEREDO	-31.04 **	-0.66 *	26.58 **	0.15 *	0.06	0.02	0.67
SPV 1359	-7.87	0.63 *	-16.03 **	-0.03	-0.62 *	-9.38 **	0.42
SPV 1411	-17.62 *	2.22 **	-12.83 *	0.31 **	1.33 **	-8.63	0.13
S.Em.±	7.32	0.27	5.48	0.06	0.1	4.39	0.52
CD at 5%	20.50	0.78	15.34	0.17	0.29	12.31	1.46
CD at 1%	27.22	1.03	20.38	0.22	0.39	16.36	1.94

the testers, NTJ 2 was good general combiner for all characters studied except juice yield (g/plant), whereas E 36-1 was the good general combiner for all the characters except cane weight (g/plant) and grain yield (g/plant). The other tester, GD 65008 was the next best general combiner with desirable significant *gca* effects for cane weight, Brix per cent, juice yield and total sugars. The results implies that three lines and three 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 38 × GD 65008, ICSA 38 × SPV 1359, ICSA 102 × E 36-1 and ICSA 38 × ICSV 25263 for cane weight, ICSA 102 × NTJ 2, ICSA 38 × ICSR 93034, ICSA 38 × SPV 1411 and ICSA 264 × SEREDO Brix per cent, ICSA 38 × GD 65008, ICSA 102 × E 36-1, ICSA 264 ×ICSR 160 and ICSA 84× SPV 1359 for juice yield, ICSA 38 × ICSR 93034, ICSA 102 × GD 65008, ICSA 264 × ICSV 91005 and ICSA 264 × ICSR 196 for reducing sugars, ICSA 38 × ICSR 93034, ICSA 264 × SEREDO, ICSA 38 × ICSR 91005 and ICSA 102 × ICSR 160 for total sugars, ICSA 264 × ICSV 91005, ICSA 38 × ICSR 56, ICSA 102 × SPV 1359 and ICSA 38 × ICSR 93034 grain yield and ICSA 102 × ICSR 160, ICSA 102 × ICSV 25263, ICSA 264 × ICSR 93034 and ICSA 84 × ICSV 574, for ethanol yield were good specific combiners (Table 3), as indicated by earlier studies (Selvi and Palanisamy, 1990; Nguyen *et al*., 1997; Laxman, 2001; Biradar *et al*., 2004).

In general, maximum crosses showing significant *sca* effects were invariably associated with better per se performance for respective traits (Table 3). The good specific combiners for different characters involved parents with high × high, high × low, low × high and low × low general combinations.

However, in majority of the cases the crosses exhibiting high sca effects were found to have both or

Table 3 : Best specific combiners (crosses) along with their sca effects, per se performance and gca status of parents

Characters	Crosses	*Per se* performance	*sca* effects	*gca* status of parents
	ICSA 38 x GD 65008	315.88	326.03 **	H × H
Cane weight	ICSA 84 x SPV 1359	448.00	237.95 **	H × L
(g/plant)	ICSA 102 x E 36-1	417.50	202.58 **	L × H
	ICSA 38 x ICSV 25263	243.17	183.15 **	H × H
	ICSA 102 x NTJ 2	14.85	4.29 **	L × H
Brix	ICSA 38 x ICSR 93034	15.25	4.15 **	H × L
(per cent)	ICSA 38 x SPV 1411	13.35	4.06 **	H × H
	ICSA 264 x SEREDO	13.45	4.00 **	L × H
	ICSA 38 x GD 65008	204.00	56.43 **	H × H
Juice yield	ICSA 102 x E 36-1	220.23	54.81 **	L × H
(g/plant)	ICSA 264 x ICSR 160	130.50	53.59 **	L × H
	ICSA 84 x SPV 1359	175.38	53.13 **	H × L
	ICSA 38 x ICSR 93034	1.50	0.60 **	H × L
Reducing sugars	ICSA 102 x GD 65008	1.60	0.44 **	L × H
(per cent)	ICSA 264 x ICSV 91005	1.90	0.36 **	L × L
	ICSA 264 x ICSR 196	1.40	0.34 **	L × L
	ICSA 38 x ICSR 93034	12.62	3.94 **	H × L
Total sugars	ICSA 264 x SEREDO	11.92	3.85 **	L × H
(per cent)	ICSA 38 x ICSR 91005	8.24	3.56 **	H × L
	ICSA 102 x ICSR 160	9.03	3.10 **	L × H
	ICSA 264 x ICSV 91005	54.50	26.93 **	L × L
Grain yield	ICSA 38 x ICSR 56	32.50	23.76 **	H × L
(g/plant)	ICSA 102 x SPV 1359	73.33	19.44 **	L × L
	ICSA 38 x ICSR 93034	63.75	18.42 **	H × L
	ICSA 102 x ICSR 160	10.35	3.61 **	L × H
Ethanol yield	ICSA 102 x ICSV 25263	9.75	3.45 **	L × H
(ml/plant)	ICSA 264 x ICSV 93046	9.80	3.43 **	L × H
	ICSA 84 x ICSV 574	5.70	3.10 **	H × L

one of the parents as good general combiners 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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