
**COMBINING ABILITY STUDIES IN GRAIN SORGHUM
[*Sorghum bicolor* (L.) MOENCH] USING LINE X TESTER
ANALYSIS**

***CHAUDHARI, D. R.¹; SOLANKI, B. G.²; NARWADE, A. V.³;
PATEL, ASHWIN⁴ AND FALDU, G. O.⁵**

**DEPARTMENT OF GENETICS AND PLANT BREEDING
N.M. COLLEGE OF AGRICULTURE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI – 396 450, GUJARAT, INDIA**

***E.MAIL: thewall.chaudhary@gmail.com**

1. Ph.D. Student, Deptt. of Genetics and Pl. breeding, N.M. College of Agri., NAU, Navsari
2. Research Scientist, Main Cotton Research Station, Athwa Farm, NAU, Surat
3. Asstt. prof., Deptt. of Genetics and Pl. breeding, N.M. College of Agri., NAU, Navsari
4. Asstt. Res. Scientist, Main Sorghum Res. Station, NAU, Surat
5. Asstt. Res. Scientist, Main Cotton Research Station, Athwa Farm, NAU, Surat

ABSTRACT

Combining ability for grain yield and its components was studied using five lines and seven testers following line x tester mating design. Mean sum of squares due to females, males and females x males were significant to highly significant indicating the existence of high variability for most of the characters. The estimates of general combining ability (gca) and specific combining ability (sca) variances indicated the presence of higher magnitude of non-additive gene action for all the characters except days to 50 per cent flowering and days to maturity. The lines 296A, AKMS-14A and 1005A and testers SR-2872 and SR-2879 were found to be good general combiners for grain yield and its contributing traits. The crosses, 1009A x SR-2872 (346.536), 1005A x Pantchari (211.482) and AKMS-14A x Nizer goti (206.119) were identified with high significant and positive SCA effects for grain yield. This suggested the usefulness of heterosis breeding or any breeding plan, which makes use of specific combining ability effects for improvement in these traits.

KEY WORDS: GCA, line x tester, SCA, *Sorghum bicolor*

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is an important crop for dry land area, which provides staple food for the poor people of world. Sorghum belongs to family *poaceae* having 2n=20 chromosomes. Sorghum is a multipurpose crop. The grain is used as human food, whereas the fodder is utilized as cattle feed, which provides milk and meat for the nourishment of human being. Sorghum is also nutritionally superior to other fine

cereals such as rice and wheat, hence, it known as nutritious cereal.

Combining ability analysis helps to get an insight into the inheritance through the predominance of general combining ability (gca) over specific combining ability (sca) variances and vice-versa. It helps the breeder to select the parents with good gca effects, crosses with good sca effects and the appropriate breeding methodology to achieve the objective quickly and reliably. The effects of gca and sca are important indicators of

potential value for inbred lines in hybrid combinations. Differences in gca effects have been attributed to additive, the interaction of additive x additive and the higher-order interactions of additive genetic effects in the base population, while differences in sca effects have been attributed to non-additive genetic variance (Falconer, 1981). The concept of gca and sca has become increasingly important to plant breeders because of the widespread use of hybrid cultivars in many crops (Wilson *et al.*, 1978). Hence, this study was conducted with the aim to understand the combining ability of the selected lines and testers in sorghum.

MATERIALS AND METHODS

Five lines viz., 296A, AKMS-14A, ICSA-467A, 1005A and 1009A and seven testers viz., B-58586, CSV-20, Kekri local, Pantchari, SR-2872, SR-2879 and Nizer goti were employed and crosses were made in line x tester mating design during *Kharif* 2014. The thirty five crosses, twelve parents and a standard check (GJ-42) were grown in a randomized block design (RBD) with three replications in three diverse environments viz., Surat, Vyara and Waghai during *kharif* 2015. The observations were recorded on five randomly selected plants for each treatment in each replication for plant height (cm), panicle length (cm) and test weight (g). The observations for days to 50 % flowering, days to maturity and grain yield per plot (g) were recorded on the plot basis. The collected data were subjected to statistical analysis to understand the magnitude of gca and sca of above mentioned parents and crosses. Data were analyzed by the methods outlined by Panse and Sukhatme (1985) to find out the significance of treatment effect. The variation among the hybrids was

further partitioned into genetic components attributable to general combining ability (gca) and specific combining ability (sca) following the method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance for combining ability over the environments revealed that mean squares due to females were significant for all the characters except viz., test weight, while the mean squares due to males were significant for all the characters excluding plant height and test weight, which indicated that both females and males contributed towards genetic variance. Highly significant mean square due to females x males was manifested by all the characters reflecting its significant contribution in favour of specific combining ability (sca) and non-additive variance (Table 1). The variance estimates, σ^2_{sca} were highly significant for all the characters, while σ^2_{gca} were significant to highly significant for all the characters except test weight emphasizing the importance of additive and non-additive gene actions, respectively, in inheritance of these characters. Perusal of $\sigma^2_{gca}/\sigma^2_{sca}$ ratio revealed the preponderance of non-additive gene action for grain yield per plot, plant height, panicle length and test weight. The importance of non-additive genetic variances for grain yield per plot and its components has been reported by several workers such as Solanki *et al.* (2007), Udutha (2008), Punitha *et al.* (2010), Tariq *et al.* (2012), Jain and Patel (2014), Thakare *et al.* (2014) and Patil and Kute (2015). Preponderance of additive gene action was recorded for the days to 50 % flowering and days to maturity. Similar result also found by Bhavsar and Borikar (2002), Rafiq *et al.* (2002) and Iyanar and Fazlullah Khan (2005).

Hence, the study suggested in general the importance of both additive and non-additive gene action for inheritance of traits studied.

The general combining ability effects (gca) of parents and specific combining ability effects (sca) of thirty five crosses are presented in Tables 2 and 3, respectively. Earliness is a desirable character, hence parents with significant negative gca effects were considered as good general combiners for the trait. Among parents, three females (AKMS-14A, ICSA-467A and 1005A) and four males (B-58586, CSV-20, SR-2879 and Nizer goti) were identified as good general combiners. Among all parents, AKMS-14A (-4.724) registered highest negative gca effects followed by B-58586 (-4.581). From total 35 crosses, 19 crosses exhibited significant to highly significant sca effects for this trait, of which 11 crosses showed significant negative sca effects (desirable). The most specific crosses were 1009A x Nizer goti (-5.489), AKMS-14A x CSV-20 (-3.876), and ICSA-467A x B-58586 (-3.721). Similar results for days to 50 % flowering was reported by Kshirsagar (2007), Udhata (2008) and Jain and Patel (2014).

For days to maturity, two females (AKMS-14A and ICSA-467A) exhibited significant and negative gca effects, whereas four males (B-58586, CSV-20, SR-2879 and Nizer goti) expressed highly significant negative gca effects. Out of 35 hybrids, eight hybrids recorded significant to highly significant negative sca effects. The cross 1009A x Nizer goti (-4.644) registered the highest negative sca effects. Such results also reported by Wadikar *et al.* (2006), Udhata (2008) and Jain and Patel (2014). Considering the sca effect in desired direction, the promising cross in respect of sca effect

having at least one parent having high gca for the days to maturity.

For plant height, gca effects revealed that parents, AKMS-14A, ICSA-467A, 1009A, B-58586, CSV-20, Pantchari and SR-2872 were found to be good general combiner for dwarfness, as they exhibited significant to highly significant gca effect in negative directions, while 296A, 1005A and Kekri local were found to be good general combiner for inducing tallness. Considering the sca effects for this trait, 12 crosses exhibited highly significant sca effects in desirable (negative) direction. Cross AKMS-14A x Pantchari recorded significantly maximum (-61.703) sca effect in desired direction, indicated that it was dwarfest hybrid. Similar results reported by Wadikar *et al.* (2006), Solanki *et al.* (2007) and Kale (2012).

With regards panicle length, among the lines, 296A (2.858) and AKMS-14A (2.074) showed highly significant and positive gca effects, whereas out of seven testers, B-58586 and SR-2872 depicted significant positive gca effect, which was desirable for this trait. Hybrids showed significant to highly significant sca effects of which only four crosses (296A x B-58586 (4.457), AKMS-14A x SR-2872 (4.326), 1009A x Kekri local (4.232) and 1005A x B-58586 (1.489)) had significant sca effect in positive (desirable) directions. The results are in accordance with the findings of Wadikar *et al.* (2006), Solanki *et al.* (2007), Udhata (2008) and Jain and Patel (2014).

Improvement in yield potential is the main goal for breeder in most of breeding programme. For this purpose selection of parents with high gca and thus, high yield potential is necessary. The results showed that three females, 296A, AKMS-14A and 1005A were noticed as good general combiners for

grain yield per plot. On the contrary, ICSA-467A and 1009A had significant and negative gca effects, hence they were categorized as poor general combiners. Out of 7 males, two male parents, SR-2872 (208.326) and SR-2879 (103.642) expressed maximum positive gca effects and proved itself good general combiners. Considering sca effects of hybrids for grain yield per plot out of 35 crosses, thirteen hybrids showed highly significant sca effects in positive direction. The best specific cross combinations in order were; 1009A x SR-2872 (346.536), 1005A x Pantchari (211.482), AKMS-14A x Nizer goti (206.119), ICSA-467A x SR-2879 (162.304), 296A x SR-2879 (127.653), AKMS-14A x B-58586 (119.454), 1005A x SR-2872 (118.659), 296A x Kekri local (117.573), 296A x B-58586 (89.140), 296A x CSV-20 (85.613), ICSA-467A x CSV-20 (83.264), 1009A x Nizer goti (78.038) and ICSA-467A x Nizer goti (54.700). Similar results were also reported by Kale (2012), Tariq et al. (2012), Jain and Patel (2014), Thakare et al. (2014) and Patil and Kute (2015). The results of sca effects indicated that specific crosses were promising of poor x poor, poor x good and good x good parents.

With respect of test weight, gca effects were positive and highly significant for females 296A, AKMS-14A and 1009A. Among the males, SR-2879 and Nizer goti exhibited positive and highly significant gca effect. The best general combiners among parents were 1009A (0.099) and Nizer goti (0.224), respectively. The range of sca effects was from -0.459 (ICSA-467A x SR-2879) to 0.311 (1009A x Pantchari) for test weight. Out of 26 significant crosses, 13 crosses showed positive sca effects. The top five crosses with higher significant and positive sca effects

were 1009A x Pantchari (0.311), 296A x CSV-20 (0.283), ICSA-467A x SR-2872 (0.274), ICSA-467A x Kekri local (0.257) and AKMS-14A x SR-2879 (0.232). Such results were also reported for test weight by Udhata (2008), Jain and Patel (2014), Thakare et al. (2014) and Patil and Kute (2015).

CONCLUSION

The outcome of the present investigation revealed that the female parent AKMS-14A and 296A was found to be good general combiners for most of the characters, while female parent, ICSA-467A exhibited poor general combining ability for most of the characters. Among male parents, SR-2872 and SR-2879 were found to be good general combiners for grain yield per plot, thereby classifying these parents as good sources of favorable genes for increasing production of grain. These male parents had also exhibited good general combining ability for two or more important yield contributing traits viz., panicle length and test weight. The highest grain yielding hybrid, 1005A X SR-2872 (good x good) had exhibited significant positive sca effect and standard heterosis over standard hybrids for grain yield as well as yield components. Thus, the study revealed that there is lot of scope for the use of these lines in future breeding programme in the development of either base populations or hybrids.

REFERENCES

- Bhavsar, V. V. and Borikar, S. T. (2002). Combining ability studies in sorghum involving diverse cytotsteriles. J. Maharashtra Agric. Uni., 27(1): 35-37.
- Falconer, D. C. (1981). An introduction to quantitative genetics. Longman, New York. Pp. 67-68.

- Iyanar, K. and Fazlullah, Khan, A. K. (2005). Combining ability analysis in forage sorghum for multi-cut habit. *Crop Res.*, 29(1): 129-133.
- Jain, S. K. and Patel, P. R. (2014). Combining ability and heterosis for grain yield, fodder yield and other agronomic traits in sorghum [*Sorghum bicolor* (L.) Moench]. *Electronic J. Pl. Breed.*, 5(2): 152-157.8
- Kale, B. H. (2012). Genetic and stability analysis for yield and yield contributing traits over different seasons in sorghum [*Sorghum bicolor* (L.) Moench] Ph.D. Thesis, Navsari Agricultural University, Navsari.
- Kemphorne, O. 1957. An Introduction to Genetic Statistics. John Willey and Sons. Ind., New York. pp. 468-470.
- Kshirsagar, R. M. (2007). Heterosis, combining ability and stability studies in grain sorghum [*Sorghum bicolor* (L.) Moench]. Ph.D. Thesis. Navsari Agricultural University, Navsari.
- Panase, V. G. and Sukhatme, P. V. (1985). Statistical Methods for Agricultural Workers. ICAR Publication, New Delhi.
- Patil, V. R. and Kute, N. S. (2015). Combining ability studies in grain sorghum. *J. Global Biosci.*, 4(1): 1902-1909.
- Punitha, D.; Subbian, P.; Ganesamurthy, K and Raveendran, T. S. (2010). Combining ability studies in sweet sorghum. *Adv. Pl. Sci.*, 23 (1): 231-235.
- Rafiq, S. M.; Thare, R. Y.; Madhusudhan, R. and Umakanth, A. V. (2002). Combining ability studies for grain yield and its components in post rainy season where sorghum grown in medium deep and shallow soils. *Int.Sorghum Millets Newsl.*, 43: 33-36.
- Solanki, B. G.; Patel, D. M.; Patel, P. B. and Desai, R. T. (2007). Combining ability analysis in sorghum [*Sorghum bicolor* (L.) Moench] for yield and its attributing traits (II) *Crop Res.*, 33 (1, 2 & 3): 187-191.
- Tariq, A. S.; Akram, Z.; Shabbir, G.; Khan, K. S. and Iqbal, M. S. (2012). Heterosis and combining ability for quantitative traits in fodder Sorghum (*Sorghum bicolor* L.). *Electronic J. Pl. Breed.*, 3(2): 775-781.
- Thakare, D. P.; Ghorade, R. B. and Bagade, A. B. (2014). Combining ability studies in grain sorghum using line x tester analysis. *Int. J. Curr. Microbiol. App. Sci.*, 3(10): 594-603.
- Udutha, J. V. (2008). Genetic study of yield and it's components in sorghum [*Sorghum bicolor* (L.) Moench]. *Indian J. Genet.*, 68 (2): 123-126.
- Wadikar, P. B.; Ambekar , S. S.; Jawarjal, S. S. and Aher, G. U. (2006). Line × Testers analysis for yield and yield contributing traits in Kharif sorghum. *J. Maharashtra Agric. Univ.*, 31(1): 73-76.
- Wilson, N. D.; Weibel, D. E and McNew, R.W. (1978). Diallel analyses of grain yield, percent protein, and protein yield in grain sorghum. *Crop Sci.*, 18 (3): 491-495.

Table 1: Analysis of variance for combining ability (Pooled over locations).

Source of variation	d.f.	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Grain Yield per Plot (g)	Test Weight (g)
Environments	2	355.466 **	270.498 **	8376.576 **	78.803 **	135416.860 **	0.347 **
Replication/Environments	4	0.909	4.812	140.620	9.852	2964.817	0.002
Females (F)	4	709.250 **	689.568 **	72085.736 **	332.949 **	679075.120 *	0.799
Males (M)	6	874.366 **	796.539 **	21747.396	90.102 **	568078.09 *	0.686
Female x Male (F x M)	34	334.948 **	314.571 **	21038.174 **	89.852 **	337655.99 **	0.503 **
Females x Environments	8	18.796	27.494	192.894	41.482 **	4491.340	0.053
Males x Environments	12	26.829	34.865	1281.944	12.259	16179.146	0.029
(F x M) x Environments	68	18.659 **	25.004 **	1258.757 **	13.571 **	12551.275 **	0.034 *
Pooled Error	204	10.410	15.919	384.431	4.456	3938.3244	0.012
Estimates							
σ^2 Environment		2.447 **	1.805 *	56.681 **	0.527	932.471 **	0.002 *
σ^2 Females		11.092 **	10.692 **	1138.115 **	5.214 *	10716.457 *	0.012
σ^2 Males		19.199 **	17.347 **	474.732	1.903	12536.439 *	0.015
σ^2 gca		14.470 **	13.465 **	861.706 **	3.834 **	11474.783 *	0.013
σ^2 sca		14.144 **	12.851 **	1329.834 **	4.979 **	24356.549 **	0.044 **
σ^2 gca/ σ^2 sca		1.023	1.048	0.648	0.770	0.471	0.295
σ^2 Females x Environments		0.399	0.551	-9.120	1.763 **	26.334	0.002
σ^2 Males x Environments		1.094	1.263	59.834	0.520	816.054	0.001
σ^2 gca x Environments		0.689	0.847	19.610	1.245 *	355.384	0.001
σ^2 sca x Environments		2.0613 **	2.068 **	348.724 **	1.596 **	3016.435 **	0.006 **

*, ** = significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 2: Estimates of general combining ability effects of crosses for various traits (Pooled over locations).

Sr.	Parents	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Grain Yield per Plot (g)	Test Weight (g)
FEMALES							
1	296A	3.467 **	3.705 **	37.839 **	2.858 **	17.293 *	0.064 **
2	AKMS-14A	-4.724 **	-4.565 **	-6.044 *	2.074 **	59.201 **	0.081 **
3	ICSA-467A	-0.946 **	-1.311 **	-38.036 **	-1.770 **	-54.091 **	-0.139 **
4	1005A	-0.819 **	-0.517	31.777 **	-1.063 **	123.091 **	-0.105 **
5	1009A	3.022 **	2.689 **	-25.536 **	-2.099 **	-145.618 **	0.099 **
	S.E. (g _i)	0.574	0.710	3.493	0.376	11.181	0.019
	C.D. at 5 %	1.133	1.401	6.887	0.747	22.046	0.039
	C.D. at 1 %	1.494	1.848	9.083	0.978	29.073	0.051
MALES							
1	B-58586	-4.581 **	-4.854 **	-6.468 *	1.473 **	-69.756 **	-0.086 **
2	CSV-20	-2.537 **	-1.965 **	-15.743 **	-1.474 **	-82.140 **	-0.037 *
3	Kekri local	8.152 **	7.702 **	46.003 **	-1.678 **	-26.445 **	-0.152 **
4	Pantchari	1.486 **	1.768 **	-19.126 **	-0.601	-53.363 **	-0.043 **
5	SR-2872	2.486 **	2.079 **	-10.361 **	2.077 **	208.326 **	0.005
6	SR-2879	-3.448 **	-3.010 **	1.381	-0.181	103.642 **	0.089 **
7	Niger goti	-1.559 **	-1.721 **	4.314	0.384	-80.265 **	0.224 **
	S.E. (g _j)	0.680	0.841	4.133	0.445	13.230	0.023
	C.D. at 5 %	1.341	1.658	8.149	0.877	26.085	0.046
	C.D. at 1 %	1.768	2.187	10.747	1.157	34.400	0.060

*, ** = significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 3: Estimates of specific combining ability effects of crosses for various traits (Pooled over locations).

Sr.	Crosses	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Grain Yield per Plot (g)	Test Weight (g)
1	296A x B-58586	-0.689	-0.638	36.690 **	4.457 **	89.140 **	-0.100 **
2	296A x CSV-20	-1.622	-2.194	30.277 **	-0.907	85.613 **	0.283 **
3	296A x Kekri local	-0.644	-0.86	-7.225	-1.680 *	117.573 **	-0.137 **
4	296A x Pantchari	-0.2	2.517	12.192	1.153	19.669	-0.178 **
5	296A x SR-2872	3.689 **	3.095 *	-39.105 **	-3.347 **	-205.376 **	0.027
6	296A x SR-2879	1.178	0.073	-30.803 **	0.089	127.653 **	0.168 **
7	296A x Niger goti	-1.711	-1.994	-2.025	0.235	-234.273 **	-0.065
8	AKMS-14A x B-58586	-3.054 **	-3.257 *	20.306 **	-2.514 **	119.454 **	0.153 **
9	AKMS-14A x CSV-20	-3.876 **	-1.702	38.026 **	0.477	14.617	-0.036
10	AKMS-14A x Kekri local	-3.676 **	-3.924 **	-43.210 **	-1.652 *	-19.612	-0.131 **
11	AKMS-14A x Pantchari	7.657 **	7.121 **	-61.703 **	1.337	-164.028 **	-0.164 **
12	AKMS-14A x SR-2872	1.546	1.254	20.999 **	4.326 **	-167.261 **	-0.185 **
13	AKMS-14A x SR-2879	0.035	-0.324	16.746 *	-1.127	10.712	0.232 **
14	AKMS-14A x Niger goti	1.368	0.832	8.835	-0.847	206.119 **	0.130 **
15	ICSA-467A x B-58586	-3.721 **	-2.956 *	-51.680 **	0.597	-126.054 **	0.207 **
16	ICSA-467A x CSV-20	-0.321	-0.289	-43.515 **	1.01	83.264 **	-0.110 **
17	ICSA-467A x Kekri local	2.546 *	2.711 *	62.649 **	-0.341	-17.154	0.257 **
18	ICSA-467A x Pantchari	-2.454 *	-2.911 *	-28.577 **	-1.041	-64.503 **	-0.122 **
19	ICSA-467A x SR-2872	-0.787	-0.778	14.314 *	-2.185 **	-92.558 **	0.274 **
20	ICSA-467A x SR-2879	1.146	0.533	18.449 **	1.184	162.304 **	-0.459 **
21	ICSA-467A x Niger goti	3.590 **	3.689 **	28.360 **	0.775	54.700 **	-0.049
22	1005A x B-58586	0.93	-0.305	19.574 **	1.489 *	-7.97	-0.238 **
23	1005A x CSV-20	-2.114	-2.860 *	6.539	0.725	-90.007 **	-0.014
24	1005A x Kekri local	4.641 **	4.584 **	-23.297 **	-0.56	-39.814	0.050
25	1005A x Pantchari	-2.692 *	-3.816 **	44.588 **	0.963	211.482 **	0.152 **
26	1005A x SR-2872	-2.803 **	-2.016	-31.099 **	0.285	118.659 **	-0.199 **

Contd....

Table 3: Contd....

Sr.	Crosses	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Panicle Length (cm)	Grain Yield Per Plot (g)	Test Weight (g)
27	1005A x SR-2879	-0.203	2.295	-10.208	-1.480 *	-87.767 **	0.074 *
28	1005A x Niger goti	2.241 *	2.117	-6.097	-1.422 *	-104.583 **	0.176 **
29	1009A x B-58586	6.533 **	7.156 **	-24.891 **	-4.030 **	-74.571 **	-0.022
30	1009A x CSV-20	7.933 **	7.044 **	-31.326 **	-1.305	-93.487 **	-0.123 **
31	1009A x Kekri local	-2.867 **	-2.511	11.083	4.232 **	-40.993	-0.040
32	1009A x Pantchari	-2.311 *	-2.911 *	33.500 **	-2.412 **	-2.62	0.311 **
33	1009A x SR-2872	-1.644	-1.556	34.891 **	0.921	346.536 **	0.083 *
34	1009A x SR-2879	-2.156 *	-2.578	5.816	1.335	-212.902 **	-0.015
35	1009A x Niger goti	-5.489 **	-4.644 **	-29.073 **	1.259	78.038 **	-0.193 **
	Sij – Skl	1.521	1.880	9.242	0.995	29.583	0.052
	Sij – Sik	1.408	1.741	8.557	0.921	27.389	0.048
	C.D. at 5 %	2.998	3.708	18.223	1.962	58.328	0.103
	C.D. at 1 %	3.954	4.890	24.032	2.587	76.921	0.136

*, ** = significant at 5 per cent and 1 per cent levels of significance, respectively.

[MS received: June 13, 2016]

[MS accepted: June 23, 2016]