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COMBINING ABILITY ESTIMATES OF PARENTS AND F_1 HYBRIDS FOR ECONOMICALLY USEFUL TRAITS OF HEXAPLOID WHEAT (*TRITICUM AESTIVUM* L.)

Mari Shah Nawaz, Bashir Ahmed Ansari, Moula Bux Kumbhar and Mohammad Ibraheem Keerio

Sindh Agriculture University, 70060, Tandojam, Pakistan.
Email of the corresponding author: shahmari21@yahoo.com

ABSTRACT

Based on the principles of Mendelian inheritance, efforts were made to estimate the general and specific combining abilities of genotypes that may foster selection of promising recombinants for future breeding programme. For the purpose, a complete diallel cross between wheat varieties *viz;* TD-1, SKD-1, IMDAD, KHIRMAN, MOOMAL and H-68 was made using Randomized Complete Block Design in four replications at Botanical Garden, Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam during 2009. Data was recorded for plant height, spikes plant^{-1}, tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1},weight of grains spike $^{-1}$, grain yield plant^{-1} and 1000-grains weight. The results of GCA showed that the varieties Moomal and Khirman proved best general combiners for all the traits under study. In the F_1 generation the cross SKD-1 x Khirman secured highest SCA value for grain yield plant^{-1}, grains spike^{-1}, spikelets spike^{-1} and tillers plant^{-1}. While reciprocal cross, Khirman x TD-1 in F_1 obtained highest SCA value for grain yield plant^{-1}, 1000-grains weight, grains spike^{-1}, spike length and spikes plant^{-1}.

Key-words: *Triticum aestivum;* Diallel crosses, general and specific combining abilities, yield related traits of wheat, Pakistan.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the "versatile cereal food" and represented as the "stuff of life" or "king of cereals" (Borlaug 1968). It belongs to Family Poaceae and considered to be one of the first domesticated cereals. Presently wheat is grown worldwide including Europe, West Asia, North Africa (CIMMYT, 2009). In Pakistan it stands first in cereals and occupies about 66% of the annual cropped area (GOP, 2006). Some of the earliest remains of the crop have been found in Syria, Jordan, Turkey, Iraq, Egypt, India China and England, moreover, wheat was first grown in the United States 1602 on an Island of the Massachusetts coast (Gibson and Benson, 2002). Wheat has been the most important grain and staple food for more than one third of the world including Pakistan. The primary goal of country's wheat breeders is to develop broadly adapted, high yielding germplasm with high yield stability, durable disease resistance and acceptable end-use quality within the context of each environment. Emphasis must also be given to the maintenance and expansion of useful genetic diversity within the germplasm targeted to each environment to help encounter the potential negative effects of genetic uniformity. Considering that the yield potential is quantitative and based on minor genes with additive effects, the breeding approach that builds on the past achievements by retaining most of the desired gene combinations and allowing selection for additional additive genes offers a promise to continue increasing the yield potential. Inferences in general also conclude that higher yields are harvested if potential genotypes are brought under cultivation that can withstand variety of environments (Inamullah *et al*., 2006). General and specific combining ability values (estimates) of parental entries and crosses and determining the genetic retrospect of dominant and recessive parents through diallel cross techniques have been the most conventional breeding strategies in developing the desired/targeted wheat cultivars.

In quantitative genetics, two types of combining ability, viz., general combining ability and specific combining ability are considered. General combining ability (GCA) refers to the average performance of a parental line as reflected in its hybrid combinations, while specific combining ability (SCA) refers to the performance of a particular cross. Furthermore, the knowledge about behavior of quantitative character like yield is very much important (Porfiri *et al*., 2001).

The data reported in this research paper deals with analyses of genotypes derived from a six-parent complete diallel cross of hexaploid wheat (*Triticum aestivum,* L.), investigating combining abilities of parental lines and their hybrid combination in F_1. Such biometrical-genetic analysis of diallel cross will delineate which parental lines, used in this study, are preponderantly dominant and in which direction (whether with increasing or decreasing attributes with respect to a particular character) so that selection of desired/targeted parents and their hybrid combinations (on

the basis of their general and specific combining ability estimates) be made in the objected cultivar development programme.

MATERIALS AND METHODS

The experimental material comprised of six hexaploid wheat (*Triticum aestivum*, L.) varieties. 15 all possible one-way crosses and 15 reciprocals in the F_1 and F_2 generations were prepared in the Botanical Garden, Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam during 2008 to 2010. Varieties included were TD-1, SKD-1, IMDAD, KHIRMAN, MOOMAL and H-68.

Observations recorded: Plant height, Number of spikes plant^{-1}, tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, weight of grains spike^{-1}, grain yield plant^{-1} and 1000-grains weight.

Statistical analysis: General and specific combining ability analyses were performed after Griffing (1956) following Method-1 (complete diallel table) and Model-1 where the experimental material is assumed to be the random sample of population about which the inferences are to be made.

RESULTS

As per Table 1, in the F_1 diallel set, mean squares for general combining ability were highly significant ($P<0.01$) for plant height, tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1} and grain yield plant^{-1} whereas mean squares for specific combining ability were significant ($P<0.05$) for tillers plant^{-1} and highly significant ($P<0.01$) for plant height, spike length, spikelets spike^{-1}, grains spike^{-1}, grains weight spike^{-1}, 1000-grain weight and grain yield plant^{-1}. Reciprocal mean squares were highly significant ($P<0.01$) for plant height, tillers plant^{-1}, spike length, spikelets spike^{-1} and grains spike^{-1}. Significance of mean squares for general and specific combining ability and reciprocal effects imply importance of these characters in the selection process for various parents, hybrids and reciprocals respectively. Variances for general and specific combining ability were of smaller magnitude but even then variances for specific combining ability were larger than those of GCAs for all the characters under study. Variances for reciprocal effects were even larger than the variances of SCAs. This implies that selection on the basis of SCAs should be given importance/priority in the cultivar breeding/development programme for any targeted character. This is supported by the estimates of non-additive component due to SCAs which was larger than the additive component due to GCAs for all the characters. GCA/SCA variance ratio also supported this interpretation as it was less than unity for all the characters under study. Earlier findings concluded similar results for most of the traits studied (Khaliq *el al.,* 2006, Khan *el al.,* 2007, Joshi *et al*., 2003 and Nazir *et al.,* 2005).

The estimates of general combining ability effects: The estimates of general and specific combining ability in the F_1 diallel set for all the characters under study are presented in Tables-2 and 3. With respect to general combining ability estimates in the F_1 diallel set (Table-2), maximum GCA value of 3.69 for plant height was scored by H-68 followed by second highest parent Imdad (GCA=2.16) whereas the lowest value of -2.55 was given by TD-1 followed by Khirman (-2.48). For spikes per plant, Moomal scored highest GCA (0.06) followed by Khirman (0.05) and the lowest GCA was given by Imdad (-0.1) followed by H-68 (-0.04). For number of tillers plant^{-1}, Moomal ranked highest (GCA=1.61) followed by TD-1 (0.90) while H-68 was the lowest (-1.10) followed by Khirman (-0.70) as second lowest. For spike length, Moomal secured highest GCA (0.69) followed by SKD-1 (0.54) and H-68 was the lowest (GCA= -1.28) followed by second lowest parent Imdad with -0.27 GCA. For number of spikelets spike $^{-1}$, Moomal had the highest GCA value of 1.09 followed by TD-1 (0.68) and Imdad ranked lowest (GCA= -1.20) followed by H-68 with -0.97 GCA value. With respect to grains spike^{-1}, Khirman gave highest GCA value of 2.19 followed by 1.56 of SKD-1 whereas Imdad ranked lowest with -3.78 GCA followed by -0.76 of H-68. For weight of grains spike^{-1}, Khirman ranked highest (GCA= 0.11) followed by Moomal with 0.10 GCA value whereas H-68 was the lowest (GCA= -0.1) followed by Imdad with second lowest GCA value of -0.09. For 1000-grains weight, the highest GCA of 0.50 was scored by Moomal followed by 0.48 value given by H-68 whereas the lowest ranking parent was TD-1 (GCA = 0.44) followed by second lowest value of -0.29 given by Imdad. Finally for yield of grains plant^{-1}, the highest GCA was exhibited by Moomal (0.66) followed by 0.55 of SKD-1 whereas the lowest GCA was obtained from Imdad (-0.86) followed by second lowest value given by TD-1 (-0.26). The results of present study are in confirmation with those of Ajmal *et al.* (2003), Kashif *et al.* (2003), Awan *et al.* (2005) and El-Awady (2006).

Table 1. Mean squares from the analysis of variance of general and specific combining ability together with estimates of other related parameters from 6x6 F_1 complete wheat diallel cross for nine quantitative characters.

Source of variation in the ANOVA and combining ability parameters	D.F.	Plant height	Spikes Plant^{-1}	Tillers Plant^{-1}	Spike length	Spike-lets spike^{-1}	Grains Spike^{-1}	Wt. of grains spike^{-1}	1000-grains weight	Grain yield per plant
F_1 DIALLEL CROSS DURING 2009										
Replications	3	102.21**	2.64	1.35	1.07	4.09	49.78*	0.69	26.5*	24.2*
GCAs	5	75.87**	0.04	12.9**	6.422**	10.1**	55.113**	0.098	1.977	3.7**
SCAs	9	43.06**	0.07	2.3*	1.957**	9.12**	130.69**	0.16**	4.102**	8.0**
Reciprocals	15	18.02**	0.02	6.4**	5.145**	9.46**	19.516**	0.027	0.540	1.1
Error	87	2.39	0.17	0.2	0.235	0.189	8.779	0.063	0.972	0.7
Variances of GCAs	-	0.167	0.01	0.01	0.016	0.013	0.610	0.004	0.068	0.05
Variances of SCAs	-	0.433	0.03	0.05	0.042	0.034	1.585	0.011	0.176	0.13
Variances of Reciprocals	-	1.199	0.08	0.14	0.117	0.094	4.389	0.031	0.486	0.36
GCA/SCA Variance Ratio	-	0.151	0.11	0.51	0.299	0.093	0.032	0.028	0.027	0.035
Component due to GCA (Additive)	-	6.123	-0.01	1.05	0.516	0.828	3.861	0.003	0.084	0.254
Component due to SCA (Nonadditive)	-	40.660	-0.09	2.07	1.722	8.935	121.920	0.105	3.130	7.352
Component due to Reciprocals	-	7.811	-0.07	3.10	2.455	4.639	5.369	-0.018	-0.216	0.182

The estimates of specific combining ability effects: With respect to specific combining ability estimates of one-way hybrids in the F_1 diallel set (Table-2), highest SCA for plant height was scored by TD-1 x Khirman (SCA=8.82) followed by second highest of 3.87 given by SKD-1 x Imdad whereas the lowest SCA of -5.31 was given by SKD-1 x Khirman followed by -4.66 value given by Imdad x Khirman. For spikes plant^{-1}, highest SCA was scored by Imdad x Khirman (0.35) followed by -0.20 of TD-1 x SKD-1 whereas the lowest SCA was given by TD-1 x Imdad (-0.22) followed by -0.18 SCA value of Khirman x H-68. For tillers plant^{-1}, highest SCA value of 2.53 was obtained from hybrid SKD-1 x Khirman followed by 1.00 given by Imdad x H-68 whereas SKD-1 x Moomal gave the lowest SCA value of -1.66 followed by TD-1 x Khirman giving -1.0 SCA. For spike length, highest SCA of 1.38 was given by TD-1 x Khirman followed by 1.36 given by TD-1 x H-68 while lowest SCA value of -1.89 was scored by TD-1 x Imdad followed by second lowest of -1.48 given by hybrid Khirman x H-68. For spikelets spike^{-1}, hybrid SKD-1 x Khirman ranked highest (SCA=4.48) followed by second highest value of 2.76 given by TD-1 x Imdad whereas TD-1 x Khirman ranked lowest with -2.27 SCA followed by second lowest value of -2.16 of Imdad x Khirman. For grains spike^{-1}, highest SCA of 12.46 was given by SKD-1 x Khirman followed by 11.22 given by Moomal x H-68 whereas the lowest ranking hybrid was SKD-1 x Imdad with -6.98 SCA value followed by -6.17 of TD-1 x Imdad. For weight of grains spike^{-1}, highest SCA of 0.27 was obtained from TD-1 x H-68 followed by 0.18 of Khirman x Moomal whereas lowest SCA value of -0.39 was given by TD-1 x Khirman followed by second lowest value of SKD-1 x Imdad (SCA= -0.20). For 1000-grains weight, highest SCA of 1.79 was obtained from hybrid Moomal x H-68 followed by 1.48 value given by SKD-1 x H-68 whereas lowest ranking hybrid was SKD-1 x Imdad with -1.39 SCA value followed by second lowest value of -0.76 given by three crosses, TD-1 x Moomal, Imdad x Khirman and Imdad x Moomal, simultaneously. Finally for grains yield plant^{-1}, highest SCA ranking hybrid was SKD-1 x Khirman (SCA= 1.93) followed by SKD-1 x H-68 (SCA=1.29) whereas the lowest estimates of -2.66 were obtained from SKD-1 x Imdad followed by second lowest of -1.45 given by hybrid TD-1 x Moomal. Similar research findings are reported by Oettler *et al*. (2003), Singh and Singh (2003) and Sharma *el al*. (2004).

Table 2. General and specific combining ability estimates from 6x6 F_1 complete diallel cross of wheat for nine quantitative characters during 2009.

Parents and their hybrids	Plant height	Spikes Plant^{-1}	Tillers Plant^{-1}	Spike length	Spike-lets spike^{-1}	Grains Spike^{-1}	Wt. of grains spike^{-1}	1000-grains weight	Grain yield plant^{-1}
GENERAL COMBINING ABILITY ESTIMATES OF THE PARENTS									
TD-1	-2.55	0.02	0.90	0.44	0.68	-0.15	-0.04	-0.44	-0.26
SKD-1	-0.01	-0.10	-0.17	0.54	0.41	1.56	0.01	0.00	0.55
IMDAD	2.16	0.02	-0.53	-0.27	-1.20	-3.78	-0.09	-0.29	-0.86
KHIRMAN	-2.48	0.05	-0.70	-0.11	-0.01	2.19	0.11	-0.26	-0.16
MOOMAL	-0.82	0.06	1.61	0.69	1.09	0.94	0.10	0.50	0.66
H-68	3.69	-0.04	-1.10	-1.28	-0.97	-0.76	-0.10	0.48	0.07
SPECIFIC COMBINING ABILITY ESTIMATES OF ONE-WAY HYBRIDS									
TD-1 x SKD-1	-3.73	0.20	0.39	0.34	-0.27	2.00	0.10	-0.40	-1.05
TD-1 x IMDAD	-0.44	-0.22	-0.91	-1.89	2.76	-6.17	0.07	-0.46	1.26
TD-1 x KHRMAN	8.82	-0.06	-1.00	1.38	-2.27	-1.40	-0.39	0.25	-0.91
TD-1 x MOOMAL	-2.58	0.12	0.45	-0.33	-0.30	0.00	0.07	-0.76	-1.45
TD-1 x H-68	1.42	-0.03	0.22	1.36	-0.70	-5.67	0.27	0.21	0.70
SKD-1 x IMDAD	3.87	-0.10	-0.88	0.59	-1.56	-6.98	-0.20	-1.39	-2.66
SKD-1 x KHIRMAN	-5.31	-0.08	2.53	0.38	4.48	12.46	-0.19	1.09	1.93
SKD-1 x MOOMAL	-0.60	0.03	-1.66	0.20	-1.50	-4.63	0.17	-0.63	-0.32
SKD-1 x H-68	1.36	0.13	0.94	-0.41	-0.76	5.06	0.03	1.48	1.29
IMDAD x KHIRMAN	-4.66	0.35	-0.57	0.01	-2.16	-2.96	0.14	-0.76	-1.62
IMDAD x MOOMAL	0.14	0.08	0.38	0.69	2.01	-6.30	-0.15	-0.76	-0.87
IMDAD x H-68	-2.44	-0.14	1.00	1.27	1.09	4.00	0.10	-0.29	-0.19
KHIRMAN x MOOMAL	-0.06	-0.15	0.65	0.47	0.70	10.62	0.18	0.71	1.19
KHIRMAN x H-68	0.13	-0.18	-0.13	-1.48	2.00	-5.64	-0.01	-0.36	0.82
MOOMAL x H-68	-0.26	-0.04	0.38	0.46	-0.96	11.22	-0.19	1.79	1.10
SPECIFIC COMBINING ABILITY ESTIMATES OF RECIPROCAL CROSSES									
SKD-1 x TD-1	-4.95	-0.30	2.70	1.95	3.83	8.06	-0.08	0.53	1.90
IMDAD x TD-1	-2.33	-0.23	-2.24	-2.24	0.17	-0.24	-0.09	-0.79	0.47
KHRMAN x TD-1	-2.60	0.07	0.62	2.50	0.85	8.82	-0.23	1.30	2.03
MOOMAL x TD-1	3.03	-0.04	-2.95	-2.13	-4.24	-0.50	-0.11	-0.33	-0.12
H-68 x TD-1	0.03	-0.04	1.95	1.45	-0.59	-0.50	-0.11	-0.35	-0.15
IMDAD x SKD-1	1.19	-0.04	-0.82	1.44	-1.20	-0.47	-0.11	-0.33	-0.12
KHRMAN x SKD-1	-4.00	-0.04	2.83	2.39	4.04	-0.64	-0.11	-0.35	-0.15
MOOMAL x SKD-1	-1.23	-0.03	-2.11	0.27	0.37	-0.51	-0.11	-0.34	-0.16
H-68 x SKD-1	-1.61	-0.04	0.72	-0.16	1.02	-0.62	-0.11	-0.36	-0.16
KHRMAN x IMDAD	0.72	-0.04	0.06	0.56	0.09	-0.51	-0.11	-0.34	-0.12
MOOMAL x IMDAD	0.69	-0.04	0.09	0.09	0.13	-0.51	-0.11	-0.36	-0.15
H-68 x IMDAD	0.74	-0.04	0.06	0.31	0.09	-0.48	-0.11	-0.34	-0.12
MOOMAL x KHIRMAN	-6.17	-0.04	2.70	2.49	3.57	-0.64	-0.11	-0.35	-0.15
H-68 x KHIRMAN	4.02	-0.04	0.49	0.46	2.38	-0.52	-0.11	-0.35	-0.16
H-68 x MOOMAL	3.49	-0.04	-1.55	-1.52	-0.12	-0.62	-0.11	-0.36	-0.15

Table 3. Relationship of parental performance and general combining ability with specific combining ability estimates in a 6×6 complete F_1 wheat diallel cross for nine quantitative characters.

Source of variation in the ANOVA and combining ability parameters	Plant height	Spikes plant	Tillers Plant^{-1}	Spike length	Spike-lets spike^{-1}	Grains Spike^{-1}	Wt. of grains spike-1	1000-grains weight	Grain yield per plant
ONE-WAY F_1 CROSSES DURING 2009									
Parent with highest mean value	H-68	Khirman	TD-1	TD-1	SKD-1	TD-1	SKD-1	Imdad	SKD-1
	88.83	5.48	12.13	10.91	20.38	82.53	14.17	47.21	20.59
Parent with lowest mean value	TD-1	SKD-1	H-68	H-68	H-68	H-68	Imdad	Khirman	H-68
	70.70	4.85	6.33	7.87	17.18	61.62	13.55	43.54	15.78
	-10.69	-8.71	-39.69	28.25	-42.44	-22.36	-2.89	-6.23	-22.50
Parent with highest GCA	H-68	Moomal	Moomal	Moomal	Moomal	Khirman	Khirman	Moomal	Moomal
	3.69	0.06	1.61	0.69	1.09	2.91	0.11	0.50	0.66
Parent with lowest GCA	TD-1	H-68	H-68	H-68	Imdad	Imdad	H-68	Imdad	Imdad
	-2.55	-0.04	-1.10	-1.28	-1.20	-3.78	-0.10	-0.29	-0.86
Hybrid with highest SCA	TD-1 x Khir	Imdad x Khir	SKD1 x Khir	TD-1 x Khir	SKD1 x Khir	SKD1 x Khir	TD-1 x H-68	Moo x H-68	SKD1 x Khir
	8.82	0.35	2.53	1.38	4.48	12.46	0.27	1.79	1.93
Hybrid with lowest SCA	SKD-1 x Khir	TD-1x Imdad	SKD1 x Moo	TD-1x Imdad	TD-1 x Khir	SKD1xImdad	TD-1 x Khir	SKD1xImdad	Imdad x Khir
	-5.31	-0.22	-1.66	-1.89	-2.27	-6.98	-0.39	-1.39	-1.62
RECIPROCAL F_1 HYBRIDS DURING 2009									
Parent with highest mean value	H-68	Khirman	TD-1	TD-1	SKD-1	TD-1	SKD-1	Imdad	SKD-1
	88.83	5.48	12.13	10.91	20.38	82.53	14.17	47.21	20.59
Parent with lowest mean value	TD-1	SKD-1	H-68	H-68	H-68	H-68	Imdad	Khirman	H-68
	70.70	4.85	6.33	7.87	17.18	61.62	13.55	43.54	15.78
	-5.92	-2.64	-27.53	-35.17	-39.43	-16.88	0.84	-2.76	-20.39
Parent with highest GCA	H-68	Moomal	Moomal	Moomal	Moomal	Khirman	Khirman	Moomal	Moomal
	3.69	0.06	1.61	0.69	1.09	2.91	0.11	0.50	0.66
Parent with lowest GCA	TD-1	H-68	H-68	H-68	Imdad	Imdad	H-68	Imdad	Imdad
	-2.55	-0.04	-1.10	-1.28	-1.20	-3.78	-0.10	-0.29	-0.86
Hybrid with highest SCA	H-68 x Khir	Khir x TD-1	Khir x SKD1	Khir x TD-1	Khir x SKD1	Khir x TD-1	SKD1 x TD-1	Khir x TD-1	Khir x TD-1
	4.02	0.07	2.83	2.50	4.04	8.82	-0.08	1.30	2.03
Hybrid with lowest SCA	Moo x Khir	SKD1 x TD-1	Moo x TD-1	Imdad xTD-1	Moo x TD-1	Moo x Khir	Khir x TD-1	H-68 x SKD1	H-68 x SKD1
	-6.17	-0.30	-2.95	-2.24	-4.24	-0.64	-0.23	-0.36	-0.16

ABBREVIATIONS: Khir = KHIRMAN Moo = MOOMAL

Specific combining ability estimates of the reciprocal F_1 hybrids in Table-2 are also separately discussed. For plant height, the maximum SCA estimates were given by cross H-68 x Khirman (SCA=4.02) followed by second highest value of 3.49 given by H-68 x Moomal whereas the lowest value was scored by Moomal x Khirman (-6.17) followed by second lowest estimates of -4.95 exhibited by SKD-1 x TD-1. For number of spikes plant^{-1}, the highest ranking hybrid was Khirman x TD-1 (0.07 SCA value) while the lowest value of -0.30 was given by SKD-1 x TD-1 followed by second lowest ranking hybrid Imdad x TD-1 with -0.23 SCA value. For tillers plant^{-1}, maximum SCA of 2.83 was scored by Khirman x SKD-1 followed by second highest value of 2.70 given by two hybrids simultaneously, SKD-1 x TD-1 and Moomal x Khirman whereas the lowest SCA value of -2.95 was scored by Moomal x TD-1 followed by second lowest of -2.24 given by reciprocal cross Imdad x TD-1. For spike length, maximum SCA was scored by Khirman x TD-1 (SCA=2.50) followed by hybrid Moomal x Khirman giving 2.49 SCA value whereas the lowest SCA estimates were given by Imdad x TD-1 (SCA= -2.24) followed by -2.13 given

by Moomal x TD-1. For spikelets spike^{-1}, Khirman x SKD-1 exhibited maximum SCA value of 4.04 followed by 3.83 given by SKD-1 x TD-1 whereas the lowest SCA score of -4.24 was scored by Moomal x TD-1 followed by second lowest value of -1.20 given by Imdad x SKD-1. For grains spike^{-1}, maximum SCA estimates of 8.82 were determined by Khirman x TD-1 followed by second highest SCA value of 8.06 given by SKD-1 x TD-1 and the lowest ranking hybrid was Moomal x Khirman giving -0.64 SCA value followed by second lowest value -0.62 given by cross H-68 x SKD-1. In case of weight of grains spike^{-1}, highest SCA value of -0.08 (negative SCAs in all reciprocal hybrids in this case) was given by reciprocal cross SKD-1 x TD-1 followed by second highest value (SCA= -0.09) given by Imdad x TD-1 whereas the lowest ranking hybrid was Khirman x TD-1 giving -0.23 SCA value followed by second lowest value of -0.11 given by all the rest of 12 reciprocal hybrids simultaneously. For 1000-grains weight, highest SCA of 1.30 was given by Khirman x TD-1 followed by second highest value of 0.53 given by SKD-1 x TD-1 whereas the lowest estimates were given by Imdad x TD-1 (SCA=0.79) followed by -0.36 of H-68 x SKD-1 and other two reciprocals at the same time. Finally for grain yield/plant, the maximum SCA of 2.03 was exhibited by Khirman x TD-1 followed by second highest ranking hybrid SKD-1 x TD-1 (SCA=1.90) whereas the lowest score of -0.16 was given by three hybrids at the same time followed by second lowest value of -0.015 given by five other reciprocal hybrids simultaneously, inferences derived from current study matches with those of documented by Siddiqui *et al.* (2004), Chowdhry *et al.* (2005), Hassnain *et al.* (2005) and Saeed *et al.* (2005).

DISCUSSION

It is reiterated by contemporary workers like Farooq *et, al* ,(2006) that the first and the foremost striking point in the combining ability analysis would come to the mind that parents with highest mean value for a particular character do not always give highest GCA estimates for that corresponding character. Theoretically, the GCA effects/estimates of a particular parent are based on the deviation of the parental mean from general parental mean and all GCA effects when summed result in more or less zero, the null hypothesis in this case would be that the highest mean value of a particular parent would expect highest GCA estimates of that parent for that particular character. Thus present conclusion that parental performance is not positively or negatively correlated with GCA estimates of that parent negates the null hypothesis formulated. Examples are obtained from Table-4 and Table-5 which explain the relationship of parental performance of GCAs, and SCAs. However, the exceptions are also available in the present results. In the F_1 diallel, only for plant height, parent H-68 with highest mean height value of 88.83 cm also secured highest GCA value of 3.6. The second most glaring example or dogma in the present results of the combining ability analysis is that the general combining ability is not correlated with the specific combining ability. In other words, parents with highest general combining ability estimates do not always produce hybrids with highest specific combining ability estimates. Let us cite examples for this conclusion. From the results in F_1 diallel set (Table 4), Moomal secured highest GCA value of 0.06 for spikes plant^{-1} but the hybrid with highest SCA value was Imdad x Khirman (SCA = 0.35) and in the reciprocal crosses the highest SCA for spikes plant^{-1} was obtained from Khirman x TD-1 (0.07 SCA value). Again for grain yield plant^{-1}, Moomal scored highest GCA of 0.66 but the highest SCA scoring hybrid was SKD-1 x Khirman and reciprocal cross Khirman x TD-1 (SCA = 2.03). To summarize this conclusion, out of nine characters studied, only one character in F_1 one-way hybrids, that is for 1000-grains weight, Moomal with highest GCA value of 0.50 also produced hybrid Moomal x H-68 with highest SCA value of 1.79. In the reciprocal F_1 crosses, for grains per spike, Khirman with highest GCA value of 2.91 also yielded hybrid Khirman x TD-1 with highest SCA value of 8.82 claiming exception to this conclusion in the F_1 diallel set. The third conclusion, and that also very conspicuous, was that sometimes parents with lowest GCA values produced hybrids with highest SCA values. Two examples out of nine characters have been found in the F_1 diallel set to support this conclusion. These are for plant height and weight of grains spike^{-1} where lowest GCA value securing parent TD-1 (GCA = -2.55) and H-68 (GCA = - 0.10) respectively gave highest SCA scoring hybrids TD-1 x Khirman (SCA = 8.82) and TD-1 x H-68 (SCA = 0.27) for the corresponding characters. The conclusions drawn are supported by Iqbal and Khan, (2006) and Abate *et al.* (2007).

Finally we wanted to see if the hybrid scoring highest specific combining ability for grains yield per plant also scored highest SCA for yield components. In the F_1 diallel set, SKD-1 x Khirman securing highest SCA value for grain yield plant^{-1} also scored highest SCA estimates for three yield components, viz., grains spike^{-1}, spikelets spike^{-1} and tillers plant^{-1}. In the reciprocal crosses, Khirman x TD-1 obtaining highest SCA value for grain yield per plant scored highest SCA values for four yield components, viz., 1000-grains weight, grains spike^{-1}, spike length and spikes plant^{-1}.

Conclusion

Precisely, GCA was not correlated with SCA. Parents with lowest GCA estimates produced sometimes hybrids with highest SCA estimates. The highest scoring SCA hybrid for a particular character did not always yield highest SCA value for that corresponding character in its reciprocal cross in the F_1. In most of the characters studied, the magnitude of highest SCA values was higher in the one way hybrids than the reciprocal crosses. Finally, the hybrid scoring highest SCA value for grain yield per plant also scored highest SCA value for two to three yield components in the F_1 generation diallel. One can rely upon hybrids developed via conventional breeding approach using principles of Mendelian genetics, as the methodology plus individuals derived from such methodology are tested and proved to be successful in different time and space.

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