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Research Article

Combining ability and gene action study for grain yield and its attributing traits in bread wheat

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Abstract

Combining ability and nature of gene interactions that contribute to grain yield and its attributing traits of wheat were investigated using 28 bread wheat hybrids developed by crossing 8 commercial varieties in a diallel mating design. The results revealed that mean squares due to GCA and SCA were highly significant for all the characters studied and indicatethe occurrence of both additive and non-additive type of gene interactions. The GCA and SCA ratio (σ^2GCA/σ^2SCA) was less than unity for all the traits except for days to 50 % flowering, number of spikelets per main spike, days to maturity and biological yield per plant. This indicated that non-additive components played relatively greater role in the inheritance of these traits. The estimate of GCA effects indicated that the parents GW-366, GW-411, K-583, KRL-213 and LOK-1, were identified as good general combiners revealing their ability in transmitting additive genes in the desirable direction to their progenies. The hybrids *viz.*, GW-366 x HD-2687, GW-366 x LOK-1 and LOK-1 x KRL-213 were found to be the best specific crosses for grain yield per plant in which GW-366 x HD-2687 was found to be the best specific combiner for number of effective tillers per plant, length of main spike, number of spikelets per main spike, number of grains per main spike, 100 grain weight, biological yield per plant and harvest index (%), therefore, can be further exploited for selection of transgressive segregants.

Key words: Wheat , combining ability, Grain yield, hybrid, yield Components.

Introduction:

India is one of the wheat producing countries of the world. It produced 94.88 million tonnes wheat on an area of 29.90 million hectare (3173.24 kg/ha) (Anonymous, 2013) but geometrical increase in India's population has been a challenge for agricultural scientists. To feed the ever-increasing population of India, there is a dire need of improving genotypes for better wheat yield potential per unit area basis. This could be achieved by exploring the maximum genetic potential from the available germplasm of wheat. Breeders should concentrate on development of productive wheat varieties by crossing good general combining lines for grain yield and selecting transgressive segregants from the resulting hybrids. Information regarding general and specific combining ability of wheat genotypes is a prerequisite to launch a successful wheat-breeding program. Diallel mating design has been extensively used to analyze the combining ability effects of wheat genotypes and also to provide information regarding genetic mechanisms controlling grain yield and other traits.

The present study was designed to find out the good general combining genotypes for sound breeding program and to select high yielding combiners for the development of productive wheat varieties and good specific combiners for selection of transgressive segregants.

Material and methods

Eight commercial varieties of bread wheat (*Triticum aestivum*), *viz.* GW-366, Lok-1, GW-173, HD-2687, KRL-213, RAJ-4037, GW-411 and K-583 were crossed in all possible combinations excluding reciprocals. The 10 parents and their resulting 28 F_1's were planted in a Randomized Complete Block Design, with three replications at Main Wheat Research Station, Junagadh Agricultural University, Junagadh, during *Rabi* - 2011. Each entry was planted in two rows of 3 m length, with a plant-to-plant and row-to-row distance of 10 and 22.5 cm, respectively. Standard agronomic practices were followed from sowing till harvest.

For recording observations, 5 competitive plants were randomly selected and tagged from each treatment in each replication and the average value per plant was computed for various yield and its attributing traits *viz.*, days to 50% flowering, plant height, no. of effective tillers per plant, length of main spike, no. of spikelets per main spike, peduncle length of main spike, days to maturity, no. of grains per main spike, 100 grains weight, grain weight per main spike, grain yield per plant and harvest index. The combining ability analysis was carried out according to Model-I (Fixed effect), Method-2 (Parents and one set of F_1's without reciprocals) of Griffing (1956).

Results and Discussion

The analysis of variance for combining ability for different characters has been presented in Table 1. The results revealed that mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all the characters studied. This indicated that both additive and non-additive type of gene effects imparting a vital role in the inheritance of all the traits.

The magnitude of GCA and SCA variances revealed that the SCA variances were higher than their respective GCA variances for all the characters except for days to 50% flowering, number of spikelets per main spike, days to maturity and biological yield per plant. The GCA and SCA ratio (□^{2}GCA/□^{2}SCA) was less than unity for all the traits except for days to 50% flowering, number of spikelets per main spike, days to maturity and biological yield per plant. This indicated that non-additive components played relatively greater role in the inheritance of these traits.

General combining ability effects of the parents (Table 2) revealed that none of the parents was found to be good general combiner for all the characters. An overall appraisal of GCA effects revealed that parents GW-366, GW-411, K-583, and LOK-1 were good general combiners for grain yield per plant and some of its components. K-583 ranked first in GCA effects for grain yield per plant and number of spikelets per main spike and stood second in respect of GCA effects for no. of effective tillers per plant, length of main spike and biological yield per plant. GW-366 and GW-411 showed significant GCA effects in desirable direction for length of main spike, no. of spikelets per main spike, no of grains per main spike, grain wt. per main spike, and biological yield per plant. LOK-1 showed significant GCA effects in desirable direction for days to 50% flowering, no. effective tillers per plant, penducle length of main spike, days to maturity, 100 grain weight, biological yield per plant and harvest index, which may be utilized in crossing programme to generate the genetic variability for effective selection to develop high yielding varieties as well as earliness in wheat. High gca effects are related to additive gene effects or additive × additive effects (Griffing, 1956), which represent the fixable genetic component of variance. It may therefore, be suggested that these parents with high gca effects may be extensively used in hybridization programme for the improvement of these traits.

The SCA is the deviation from the performance predicted on the basis of general combining ability (Allard, 1960). Normally SCA effects would not contribute appreciably in the improvement of self-pollinated crops except where exploitation of heterosis is feasible. However, in the production of homozygous lines, breeder's interest usually rests upon transgressive segregation shown by the crosses. The SCA effect of 28 crosses are presented in table 3. The crosses *viz.*, GW-366 x HD-2687, GW-366 x LOK-1 and LOK-1 x KRL-213 were found to be the best specific crosses for grain yield per plant. The cross GW-366 x HD-2687 was also found to be the best specific combiner in desirable direction for no. of effective tillers per plant, length of main spike, no. of spikelets per main spike, no. of grains per main spike, 100 grain weight, biological yield per plant and harvest index (%). Among crosses, the hybrids GW-173 x HD-2687 exhibited significant sca effects in desirable direction for days to 50 per cent flowering, plant height and days to maturity.

Genetic variance component indicated that both additive and non-additive type of gene effects imparting a vital role in the inheritance of all the traits. The GCA and SCA ratio (□^{2}GCA/□^{2}SCA) was more than unity for days to 50 % flowering, no. of spikelets per main spike, days to maturity and biological yield per plant. This indicated that additive components played relatively greater role in the inheritance of these traits. Therefore, mass selection or pedigree selection might be fruitful in early segregating generations for the improvement of the traits controlled by additive genes action. The GCA and SCA ratio (□^{2}GCA/□^{2}SCA) was less than unity for *viz.*, plant height, number of effective tillers per plant, length of main spike, penduncle length of main spike, number of grains per main spike, 100-grain weight, grain weight per main spike, grain yield per plant and harvest index. Therefore, selection must be delayed to late segregating generations (F_6) as in bulk method for these traits if necessary as discussed by Ahmadi *et al.* (2003) and Khaliq *et al.* (2006).

The results are in conformity with those obtained earlier by Mavi *et al.* (2003), Siddique *et al.* (2004), Dhayal and Sastry (2003), Desai *et al.* (2005), Chowdhary *et al.* (2007), Sami *et al.* (2010) and Zahid *et al.* (2011)

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Table 1. Analysis of variance for combining ability for various characters in wheat.

Source of variation	df	Days to 50 % flowering	Plant height (cm)	No. of effective tillers per plant	Length of main spike (cm)	No. of spikelets per main spike	Peduncle length of main spike (cm)	Days To maturity	No. of grains per main spike	100 Grain weight (g)	Grain weight per main spike (g)	Grain yield per plant (g)	Bio-logical yield per plant (g)	Harvest index (%)
GCA	7	22.35**	10.74**	4.40**	1.60**	22.55**	31.05**	65.55**	49.49**	0.19**	5.79**	3.17**	31.24**	44.75**
SCA	28	7.36**	3.78**	2.82**	0.28**	2.20**	4.44**	3.27**	8.81**	0.04**	1.36**	1.74**	12.25**	8.00**
ERROR	70	0.05	0.05	0.72	0.05	0.03	0.02	0.07	0.04	0.00	0.01	0.02	0.08	0.05
σ^2 GCA		22.2	1.03	0.44	0.16	2.25	3.10	6.55	4.94	0.02	0.58	0.32	31.2	4.47
σ^2 SCA		7.59	3.73	1.52	0.27	2.17	4.42	3.20	8.77	0.04	1.35	1.71	12.16	7.95
G.P.R. = σ^2 GCA /σ^2SCA		2.93	0.28	0.29	0.59	1.04	0.70	2.05	0.56	0.50	0.43	0.19	2.60	0.56

*,** significant at 5% and 1% levels, respectively.

Table 2. Estimates of general combining ability effects for different characters in wheat.

Source of variation	Days to 50 % flowering	Plant height (cm)	No. of effective tillers per plant	Length of main spike (cm)	No. of spikelets Per main spike	Peduncle length of main spike (cm)	Days to maturity	No. of grains per main spike	100 grain weight (g)	Grain Weight per main spike (g)	Grain yield per plant (g)	Bio-logical yield per plant (g)	Harvest index (%)
GW366	0.14*	0.72**	0.44	0.45**	0.81**	-1.41**	0.17*	3.91**	-0.22**	1.43**	1.42**	9.39**	-3.38**
LOK-1	-4.42**	-1.76**	2.51*	-0.14**	-1.54**	-0.46**	-1.03**	-2.13**	0.27**	-0.56**	0.30**	1.08**	1.72**
GW173	-9.04**	-7.03**	-1.29	-0.85**	-2.20**	-2.42**	-5.93**	-3.39**	-0.01	-1.22**	-3.52**	-10.55**	-1.00**
HD2687	2.28**	3.59**	-1.07	-0.17**	-1.02**	-0.90**	1.38**	1.47**	-0.08**	0.32**	-1.85**	-2.68**	-2.47**
KRL213	-0.98**	1.68**	-1.08	0.10**	-0.22**	-0.60**	0.90**	0.71**	0.00	0.09**	0.26**	-1.22**	1.18**
RAJ4037	4.11**	1.38**	-0.87	0.14**	0.63**	1.02**	1.70**	-0.65**	-0.00	-0.16**	0.71**	-0.18*	2.34**
GW411	3.76**	1.10**	-0.84	0.16**	1.60**	2.24**	1.62**	0.35**	0.03*	0.23**	1.17**	1.55**	1.72**
K583	4.15**	0.33**	2.21*	0.31**	1.96**	2.53**	1.18**	-0.27**	0.00	-0.12**	1.51**	2.61**	-0.11
SE(gi)	0.04	0.04	1.53	0.03	0.05	0.04	0.08	0.06	0.02	0.03	0.04	0.08	0.06
SE(gi-gj)	0.10	0.10	2.03	0.04	0.08	0.06	0.12	0.09	0.02	0.05	0.07	0.13	0.10

*,** significant at 5% and 1% levels, respectively.

Table 3. Estimates of specific combining ability effects for different characters in wheat.

Sr. No.	Hybrids	Days to 50 % flowering	Plant height (cm)	No. of effective tillers per plant	Length of main spike (cm)	No. of Spikelets per main spike	Peduncle length of main spike (cm)
1	GW-366 x lok-1	-0.36	-0.63**	0.88	-0.25**	-0.72**	1.98**
2	GW-366 x GW-173	0.12	2.50**	0.44	-0.11	-2.13**	-0.16
3	GW-366 x HD-2687	1.03**	2.45**	0.53	1.22**	1.46**	3.25**
4	GW-366 x KRL-213	0.50*	-2.21**	0.03	0.87**	2.36**	2.18**
5	GW-366 x RAJ-4037	-3.29**	-0.64**	0.82	-0.68**	1.30**	-0.34*
6	GW-366 x GW-411	0.12	1.21**	0.13	0.58**	1.67**	-0.86
7	GW-366 x K-583	-0.61**	-0.57**	-3.59**	-0.47**	1.27**	-2.30**
8	LOK-1 x GW-173	2.08**	-1.74**	-2.06**	-0.48**	-1.18**	1.61**
9	LOK-1 x HD-2687	-3.20**	2.59**	-3.09**	0.60**	2.80**	2.27**
10	LOK-1 x KRL-213	0.13	3.57**	-2.07**	0.63**	2.15**	1.06**
11	LOK-1 x RAJ-4037	-3.86**	-1.61**	-2.79**	0.23**	0.32*	-0.47**
12	LOK-1 x GW-411	-0.64**	3.56**	-2.37**	0.87**	0.32*	-2.13**
13	LOK-1 x K-583	1.31**	-1.65**	2.52**	0.05	0.91**	-3.10**
14	GW-173 x HD-2687	-4.49**	-3.01**	-0.12	-0.28**	-1.03**	2.96**
15	GW-173 x KRL-213	-0.13	0.94**	0.34	-0.04	1.74**	1.49**
16	GW-173 x RAJ-4037	-3.98**	1.53**	0.43	0.11	1.24**	-1.09**
17	GW-173 x GW-411	-3.02**	0.18	0.52	0.05	1.06**	-1.95**
18	GW-173 x K-583	-3.18**	0.51*	-2.13**	0.28**	-0.38*	-1.70**
19	HD-2687 x KRL-213	4.02**	1.98**	1.54**	-0.51**	0.62**	-0.10
20	HD-2687xRAJ-4037	0.03	-0.15	1.07	-0.08	-0.20	-1.68**
21	HD-2687 x GW-411	-0.59**	0.79**	0.88	0.17*	-0.90**	-2.84**
22	HD-2687 x K-583	0.42*	1.06**	-1.88**	0.19*	-0.13	-2.49**
23	KRL-213x RAJ-4037	-2.53**	-0.73**	0.71	-0.06	-1.10**	-1.35**
24	KRL-213 x GW-411	-1.45**	-0.95**	0.61	-0.30**	-1.60**	-1.54**
25	KRL-213 x K-583	-1.04**	1.14**	-2.27**	-0.23**	-1.56**	-1.00**
26	RAJ-4037 x GW-411	3.45**	0.76**	0.72	0.12	-1.16**	1.20**
27	RAJ-4037 x K-583	3.89**	-0.43*	-2.55**	0.29**	-0.65**	1.52**
28	GW-411 x K-583	1.18**	-0.96**	-2.05**	-0.43**	0.32*	3.02**
SE(Sij)		0.20	0.20	0.47	0.08	0.16	0.13
SE(Sij-Sik)		0.29	0.30	0.69	0.12	0.23	0.19
SE(Sij-Skl)		0.28	0.28	0.65	0.12	0.22	0.18

*,** significant at 5% and 1% levels, respectively.

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Table 3. Contd..

Sr. No.	Hybrids	Days to maturity	No. of grains per main spike	100 Grain weight (g)	Grain weight per main spike (g)	Grain yield Per plant (g)	Biological yield per Plant (g)	Harvest index (%)
1	GW-366 x lok-1	0.93**	3.30**	-0.23**	-0.19	2.16**	3.83**	2.27**
2	GW-366 x GW-173	0.34	0.73**	-0.34**	0.69**	0.47**	-4.50**	0.38
3	GW-366 x HD-2687	2.13**	4.19**	0.12	1.29**	2.63**	2.13**	3.00**
4	GW-366 x KRL-213	0.58*	2.69**	0.01	1.18**	0.20	1.83**	-0.32
5	GW-366 x RAJ-4037	-0.13	3.22**	0.06	0.26**	-0.17	1.89**	2.00**
6	GW-366 x GW-411	0.82**	3.81**	0.24**	2.36**	0.21	4.58**	3.81**
7	GW-366 x K-583	-0.95**	0.75**	0.06	0.30**	-0.41**	2.33**	-5.18**
8	LOK-1 x GW-173	2.28**	1.09**	0.11*	0.14	-1.22**	-2.62**	-0.40*
9	LOK-1 x HD-2687	-2.67**	-0.69**	0.13*	-0.75**	-2.55**	-4.69**	0.66**
10	LOK-1 x KRL-213	0.15	-1.16**	-0.28**	1.07**	1.17**	0.65*	-0.56**
11	LOK-1 x RAJ-4037	0.88**	1.73**	-0.28**	0.11	0.13	3.13**	-2.22**
12	LOK-1 x GW-411	1.02**	0.92**	-0.24**	-0.20*	0.88**	1.80**	-1.66**
13	LOK-1 x K-583	0.20	0.63**	-0.31**	0.09	-0.22	1.28**	-3.13**
14	GW-173 x HD-2687	-1.07**	-3.92**	0.07	-1.12**	0.07	-2.13**	-3.20**
15	GW-173 x KRL-213	-0.61*	-1.70**	0.08	-1.27**	-1.10**	-0.66*	-0.49*
16	GW-173 x RAJ-4037	-3.49**	-0.34	-0.02	-0.06	-1.46**	-0.53*	-3.54**
17	GW-173 x GW-411	-4.18**	-0.89**	0.01	-0.24*	-1.08**	0.53*	-1.44**
18	GW-173 x K-583	-1.89**	-0.22	-0.07	0.68**	-2.13**	-4.52**	1.02**
19	HD-2687 x KRL-213	0.71**	0.87**	-0.31**	-0.21*	0.26	1.68**	4.31**
20	HD-2687xRAJ-4037	-0.77**	1.09**	-0.14**	0.28**	-0.23	-4.84**	3.05**
21	HD-2687 x GW-411	-0.29	4.59**	0.08	1.02**	-0.69**	1.10**	-3.70**
22	HD-2687 x K-583	-0.61*	1.69**	0.20**	1.20**	-0.10	7.07**	-5.70**
23	KRL-213x RAJ-4037	0.39	1.42**	0.22**	0.22*	-0.27*	-0.56*	-0.47*
24	KRL-213 x GW-411	-0.30	1.45**	0.03	0.78**	-0.23	-0.06	1.45**
25	KRL-213 x K-583	-0.75**	0.15	0.12*	0.00	0.46**	0.08	2.48**
26	RAJ-4037 x GW-411	1.73**	-2.76**	-0.14**	-2.00**	0.67**	-1.11**	-1.40**
27	RAJ-4037 x K-583	0.04	-1.59**	0.08	-1.66**	-0.60**	-3.22**	1.62**
28	GW-411 x K-583	0.25	-1.40**	-0.08	-0.87**	0.65**	-1.83**	1.80**
SE(Sij)		0.24	0.18	0.05	0.10	0.13	0.25	0.20
SE(Sij-Sik)		0.35	0.27	0.07	0.15	0.20	0.38	0.29
SE(Sij-Skl)		0.33	0.26	0.06	0.14	0.19	0.36	0.27

*,** significant at 5% and 1% levels, respectively.