Combining ability and heterosis analysis for grain yield and its components in wheat

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Abstract

Parents and 40 F_1s were grown in a randomized block design with two replications. Both general combing ability (GCA) and specific combing ability (SCA) variances were significant for grain yield and all yield component characters, except GCA variances for number of productive tillers per plant, main spike weight, first inter node length and grain weight per spike and SCA variances for stem girth, thereby, indicating that grain yield and most of traits were under the control of both additive as well as non-additive inheritance. The combining ability effects revealed that parents HD2964, DDW32, DDW11 and HS493 identified as good general combiners for grain yield and for most of the characters including harvest index. The crosses, DBW39 X HPW285, SONALIKA X RAJ4119, MP4010 X HS493 and MP4010 X HD2964 were good specific combiner for grain yield and either two or more components traits. Most of the good specific combinations for various traits involved parents with high X low or low X low or low X high GCA effects. Heterosis over mid parents and better parent were significant in favorable direction in crosses viz., DBW39 X HD2964, SONALIKA X RAJ4119, SONALIKA X DDW11, DBW17 X RAJ4119, for grain yield and its components.

Key words: Bread wheat, combining ability analysis, heterosis

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Introduction

Wheat (*Triticum aestivum* L.) is the most widely cultivated crop among the cereals and is the principal food crop in most areas of the world and also occupies prominent position in Indian agriculture after rice. India is the second largest producer of wheat in the world with the production hovering around 75 million tonnes during the last decade. Wheat is a major contributor to the food security system in India as well, occupying nearly 27.54 million hectares and producing 80.58 million tonnes (Anonymous, 2009). National commission Agriculture estimated that India needs 110 million tonnes of wheat by 2020 A.D. This goal can be achieved by enhancing through the development of new cultivars having wider genetic base and better performance. Earlier research review revealed that both general and specific combining abilities were involved for yield and yield components [Chaudhry *et al.*, 1992 and Hassan *et al.*, 2006]. For effective improvement in yield of wheat, a plant breeder must have knowledge of inheritance of agronomic traits. Information of the genetic systems controlling the quantitative characters is essential to choose the most effective and efficient breeding strategy. The present investigation is planned to select parents for efficient hybridization programme as well as to identify superior cross combination for further improvement in wheat.

Materials and methods

A set of 40 F_1s was generated by crossing in Line x Tester mating design using 5 lines of bread wheat *viz.*, DBW 39, CBW 38, DBW 17, SONALIKA, and MP 4010 and 8 testers consisting 7 varieties of bread wheat *viz.*, RAJ 4119, HS 493, HD 2964, HPW 285, RAJ 4129, DDW 32, and VL 912 and one durum wheat *viz.*, DDW 11. A field experiment was conducted in randomized block design with two replications at Research Farm, College of Agriculture, Gwalior, Madhya Pradesh, India. Each entry was sown in 3 meter long single row with row to row spacing of 25 cm. Crop was grown with recommended package of practices. Observations were recorded on five randomly selected plants from each line for yield and its attributes *viz*, days to heading, days to maturity, biological yield per plant, plant height, number of productive tillers per plant, spike length, main spike length, first inter-node length, total spike weight, grain weight per spike, 1000 grain weight, grain yield per plant and harvest index. Combining ability analysis was worked out in Line X Tester mating design by following Kempthorne (1957).

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Results and discussion

Analysis of variances revealed that both general combing ability (GCA) and specific combing ability (SCA) variances were significant for days to heading, days to maturity, 1000 grain weight, biological yield, harvest index, plant height, spike length, stem girth, total spikes weight per plant; whereas specific combining ability (SCA) variances were significant for number of productive tillers per plant, main spike weight, first internode length and grain weight per spike and general combining ability variances was significant for stem girth (Table 1). Significance of both GCA and SCA variances for yield and yield components in wheat were also reported earlier by Jamini and Mathur (1990), Hassan *et al.* (2006), Kashif and Khan (2008), Burungale *et al.* (2011) and Akram *et al.* (2011).

Table 1. Analysis of variance for combining ability for grain yield and yield contributing characters in wheat

Source	d.f.	Grain yield per plant	Days to heading	Days to maturity	1000 grain weight	Biological yield per plant	Plant height	Productive tillers per plant	Spike length	Main spike weight	First Inter-node length	Stem girth	Total spikes weight per plant	Grain weight per spike	Harvest index
Lines	4	29.83**	143.30**	22.73**	3.94**	320.15**	179.87**	0.60	4.54**	0.96*	0.04	3.04**	39.23**	0.15	7.67**
Testers	7	9.18**	52.46**	6.66**	30.59**	136.67**	35.29**	1.01	2.59**	0.17	0.10	3.38**	15.03**	1.37	6.69**
L X T	28	6.35**	11.69**	6.38**	20.01**	119.82**	25.05**	0.96**	1.66**	0.28**	0.14**	1.87	10.90**	1.04**	3.94**
Error	52	2.63	3.41	1.61	1.83	50.50	3.85	0.31	0.18	0.06	0.03	1.26	8.13	0.42	1.68
Genetic components															
σ2gca (Lines)		0.0772	0.5500	0.0400	0.0060	0.6200	0.4688	-0.0003	0.0123	0.0013	-0.0004	0.0104	0.0965	-0.0008	0.0232
σ2gca(Testers)		0.3088	2.2030	0.1800	0.0260	2.4946	1.8752	-0.0013	0.0493	0.0054	-0.0016	0.0417	0.3861	-0.0032	0.0928
σ2gca(Parents)		41.92	396.62	18.19	52.68	309.84	221.42	0.52	9.02	-0.03	-0.29	11.07	55.21	1.31	21.64
σ2sca		1.86	4.14	2.38	9.08	34.66	10.60	0.33	0.74	0.11	0.06	0.30	1.39	0.31	1.13
σ2gca / σ2sca		22.54	95.75	7.64	5.79	8.94	20.88	1.60	12.20	-0.25	-5.15	36.32	39.78	4.27	19.19
σ2 A		83.83	793.24	36.39	105.36	619.68	442.84	1.05	18.04	-0.06	-0.58	22.14	110.42	2.62	43.28
σ2 D		1.86	4.14	2.38	9.08	34.66	10.60	0.33	0.74	0.11	0.06	0.30	1.39	0.31	1.13
σ2 A / σ2 D		45.08	191.50	15.28	11.59	17.88	41.76	3.20	24.39	-0.50	-10.29	72.63	79.56	8.54	38.38

**Significant at 5% level ** Significant at 1% level*

Table 2. Estimates of general combining ability effects for grain yield and yield contributing characters in wheat

Parents Line	Grain yield per plant	Days to heading	Days to maturity	1000 grain weight	Biological yield per plant	Plant height	Productive tillers per plant	Spike length	Main spike weight	First Inter-node length	Stem girth	Total spikes weight per plant	Grain weight per spike	Harvest index
DBW39	2.38**	1.61**	0.07	0.16	-3.38	-1.19**	-0.05	0.43**	0.41**	-0.02	-0.08	2.67**	0.11	0.39
CBW38	-0.09	2.33**	1.44**	-0.16	5.44**	3.28**	-0.01	-0.73**	0.04	0.09**	-0.71**	-0.56	-0.10	0.48
DBW17	-0.59	2.45**	-1.87**	-0.48	-5.55**	-3.21**	-0.22	-0.40**	-0.09	-0.03	0.18	-0.02	-0.06	0.63
SONALIKA	-0.83**	-2.33**	0.32	-0.31	0.69	3.87**	0.31**	0.24**	-0.21**	0.00	0.19	-1.38	0.10	-0.71**
MP4010	-0.86**	-4.05**	0.04	0.78**	2.80	-2.75**	-0.03	0.46**	-0.16**	-0.04	0.43	-0.70	-0.04	-0.79**
S.E.(Females)	0.41	0.46	0.32	0.34	1.78	0.49	0.14	0.11	0.06	0.04	0.28	0.71	0.16	0.32
Tester														
RAJ4119	-0.38**	-3.33**	-0.38**	1.53**	4.67	2.47**	0.38**	0.36**	-0.24**	-0.06**	-0.68**	-0.33	0.34**	-0.46**
HS493	-0.64**	-0.38**	-1.28**	-2.95**	-4.27	1.94**	-0.64**	0.36**	0.00**	-0.05**	0.38**	-1.66**	-0.24**	0.15**
HD2964	1.38**	1.02**	0.22**	0.17**	5.33	0.53**	0.30**	-0.93**	0.10**	-0.07**	-0.13**	1.32**	0.32**	0.70**
HPW285	0.76**	0.02	-0.68**	-1.87**	-4.36	-0.04	-0.02**	0.52**	0.07**	0.23**	-0.95**	0.79	0.10**	-0.85**
RAJ4129	0.92**	-2.08**	0.02	-0.84**	-2.17	0.71**	0.09**	0.17**	0.00**	0.04**	0.10**	1.89**	0.29**	-0.88**
DDW32	0.17**	3.37**	0.37**	1.17**	-1.13	-1.15**	-0.30**	-0.47**	-0.14**	-0.07**	0.60**	-1.19	0.24**	1.14**
DDW11	-1.30**	2.67**	1.47**	0.74**	1.37	-3.41**	0.09**	-0.31**	0.08**	-0.05**	0.69**	-0.45	-0.56**	0.86**
VL912	-0.91**	-1.28**	0.27**	2.05**	0.59	-1.05**	0.13**	0.30**	0.13**	0.03**	0.01	-0.37	-0.47**	-0.67**
S.E.(Males)	0.07	0.12	0.03	0.03	25.51	0.15	0.00	0.00	0.00	0.00	0.02	0.66	0.00	0.03

** Significant at 5% level,** Significant at 1% level*

The present results also revealed that main spike weight and grain weight per spike were under the control of both additive and non-additive genetic components, whereas, stem girth was under the control of additive variances. Number of productive tillers per plant and first inter-node length showed under the control non-additive genetic components. Similar results were also reported earlier by Hassan *et al.* (2007) for number of productive tillers per plant and Burungale *et al.* (2011) for main spike weight.

General combining ability effects (GCA) presented in table 2 revealed that a parent DBW 39 showed significant good general combiner for grain yield per plant, main spike weight and total spike weight; DDW 32 for days to heading and harvest index; DDW 11 for days to maturity and stem girth; VL 912 for 1000 grain weight; CBW 38 for biological yield and plant height; RAJ 4119 for productive tillers per plant and grain weight per spike; HPW 285 for spike length and first inter-node length. Rests of the parents were poor combiner for grain yield having negative or non-significant positive GCA effects. Present results are in agreement with those of Amaya *et al.* (1972) and Kassem. (1978) for days to heading, Bhatti *et al.* (1984) for days to maturity, Singh *et al.* (1990) and Mahantashivayogayya *et al.* (2004) for plant height and spike length, Yadav *et al.* (2011) for harvest index and biological yield, Emer *et al.* (2010) for grain yield per plant, Jamini and mathur (1990) for 1000 grain weight.

Specific combining ability effects (SCA) presented in table 3 revealed that crosses viz., SONALIKA X RAJ 4119, MP 4010 X HD 2964 and DBW 39 X HD 2964 recorded significant specific combining ability combinations for grain yield, MP 4010 X DDW 32 for days to heading; DBW 17 X HPW 285 for days to maturity; CBW 38 X VL912 for 1000 grain yield; MP 4010 X HD 2964 for biological yield; SONALIKA X RAJ4119 for grain weight per spike and plant height; MP 4010 X RAJ 4119 for productive tillers per plant; SONALIKA X HS 493 for spike length; CBW 38 X HPW 285 for main spike weight; CBW 38 X HPW 285 for first inter-node length; MP 4010 X RAJ 4119 for stem girth; DBW 39 X RAJ 4129 for total spikes weight per plant; SONALIKA X HPW 285 for harvest index. Most of the crosses with high SCA effects for yield had at least one good combining parent. High SCA effects in some of the crosses having good X good combining parents reflect additive X additive type gene action and superiority of favourable genes contributed by the parents. Some of the crosses with high SCA effect had one parent with good GCA effects and with poor X poor combing parents indicated additive X dominance and dominance X dominance gene action, respectively. The superiority of average X average or average X low GCA combination may be due to the presence of genetic diversity among the parents and there could be some complementation indicating importance of non-additive

Table 3. Promising crosses showing high mean yield, SCA and GCA effects for grain yield and its attributing traits

Crosses	Grain yield				SCA effects for contributing traits												
	mean	SCA Effects	GCA effects Parent (1)	GCA effects Parent (2)	Days to heading	Days to Maturity	1000 seed weight	Biological yield per plant	Plant height	Number of productive tillers per plant	Spike length	Main spike weight	1st Inter-node length	Stem girth	Total spikes weight per plant	Grain weight per spike	Harvest index
DBW39 x HPW285	20.74	3.78**	2.38**	0.76**	0.19	-1.38	-1.76	-1.68	-0.73	0.43	0.79**	0.59**	0.31**	-0.79	1.00	0.98**	0.84
SONALIKA x RAJ4119	16.20	2.733**	-0.83**	-0.38**	-3.57	-1.32	7.92**	7.67	9.96**	1.57	1.44**	0.03	0.56**	-1.15	3.06	2.80**	0.59
MP4010 x HS493	14.62	0.921**	-0.86**	-0.64**	4.14**	-1.80**	0.12	-3.82	2.25	-1.09**	-0.01	0.60**	0.44**	0.55	-1.40	0.28	1.04
MP4010 x HD2964	17.48	2.712**	-0.86**	1.38**	-2.68**	-2.37**	-1.81	21.81**	-1.10	0.89**	-2.95**	-0.96**	-0.97**	-2.12**	2.71	1.08**	1.52

** Significant at 5% level, ** Significant at 1% level* effects. The similar results were also reported earlier by Mishra *et al.* (1994) for days to heading and days to maturity, Burungale *et al.* (2011) for plant height, Sharma *et al.* (2005) and Shrivastava and Singh (2012) for spike length, Gorjanovic and Balalic (2004) for harvest index.

Heterosis over mid parent was significant in favorable positive direction in the crosses DBW 17 X RAJ 4119 and MP 4010 X HD 2964 for grain yield and most of the component traits, except latter for harvest index. Other crosses DBW 39 X HD 2964, SONALIKA X RAJ 4119 and SONALIKA X DDW 11 were also showed significant favorable positive relative heterosis for grain yield and more components. Crosses CBW 38 X RAJ 4129, DBW 17 X HS 493, DBW 17 X RAJ 4129, SONALIKA X RAJ 4129 and MP 4010 X HPW 285 showed significant relative heterosis for grain yield and seven attributing traits. DBW 17 X RAJ 4119, SONALIKA X RAJ 4119, and SONALIKA X RAJ 4129 recorded significant favorable heterosis over better parent for grain yield and its eight attributing traits. Whereas none of the cross found to be significant for standard heterosis tested over a released variety MP4010 in favorable direction for grain yield and most of the contributing characters except for harvest index, biological yield and plant height. CBW 38 X HD 2964, CBW 38 X DDW 32 and DBW 17 X DDW 36 showed significant standard heterosis in favorable direction for harvest index, biological yield and plant height.

Analysis of combining ability in the present wheat material suggested an idea about breeding methodology to be applied and use of promising crosses for further improvement in wheat. In self –pollinated crops like wheat, SCA effects are not much important as they are mostly related to non-additive gene effects excluding those of arising from complementary gene action or linkage effects they cannot be fixed in pure lines. Further superiority of the hybrids might not indicate their ability to yield transgressive segregates; rather SCA would provide satisfactory criteria and expected to throw desirable transgressive segregates in later generations. Grain yield and major yield components revealed the significance of both additive and non-additive gene action for grain yield and its different components. The presence of both significant additive and non-additive genetic variances for grain yield and major yield attributing traits suggested that high performance of yield and contributing traits can be fixed in subsequent segregating generation of SONALIKA X RAJ 4119, MP 4010 X HD 2964, DBW 39 X HPW 285 and MP 4010 X HS 493. The good general combiners may be used for varietal improvement through the recurrent selection, inter-mating and bi-parental mating in F_2 generation of promising crosses consisting parents HD 2964, RAJ 4129, DDW 32, DBW 39 and HPW 285 would be used for improvement for high yielding varieties through the simple / recurrent selection from segregating generations in wheat. This may lead in the fixation of both additive and non-additive components while making improvement in grain yield and its attributes.

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