Electronic Journal of Plant Breeding, 2(3):303-309 (Sep 2011)
ISSN 0975-928X

Research Article

Combining ability for grain yield and other related traits in bread wheat (*Triticum aestivum* L.)

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(Received:05 May 2011; Accepted:10 Jul 2011)

Abstract:
Combining ability for grain yield and other related characters was studied in 36 F_1s along with 15 parents (12 lines and three testers) which were evaluated in a completely Randomized Block Design (RBD) with three replications during *rabi* 2005-06.The results indicated that among various lines, line HD 2687 was identified as a good general combiner for the characters days to heading, days to maturity, plant height and biological yield per plant, whereas, Line UP 2338 appeared as a good general combiner for the characters, plant height, tillers per plant, spikelets per ear, spike length, grains per ear and 1000-grain weight. Line 35th IBWSN-4 for days to maturity and harvest index; Line 35th IBWSN-14 for days to maturity, grains per ear and grain yield per plant; 10th HTWYT-47 for days to heading, days to maturity, tillers per plant and grains per ear; 11th HRWYT-7 for the characters spike length, 1000-grain weight, harvest index and grain yield per plant and 4th IAT-49 for tillers per plant, plant height and harvest index were identified as good general combiners. Lines 20th SAWSN-18, CPAN 3004 and RD 1008 were identified as good general combiners for days to heading, tillers per plant and biological yield per plant, respectively. Tester PBW 373 emerged as a good general combiner for the characters days to heading and biological yield per plant, whereas, Tester PBW 502 appeared as a good general combiner for the tillers per plant. Out of 36 cross combinations, nine crosses *viz.* UP 2338/ PBW 502, 4th IAT-49 / PBW 502,11th HRWYT-16/ PBW 343,10th HTWYT-47/ PBW 343, RD 1008/ PBW 373 , 35th IBWSN-14/ PBW 502, 20th SAWSN-18/ PBW 343, 35th IBWSN-4/ PBW 502 and CPAN 3004/ PBW 373 emerged with significant positive *sca* effects for grain yield per plant. The parents involved in these crosses are average x average general combiners and or poor x average combiners except in cross 35th IBWSN-14/ PBW 502 (3.14), which involved good x average general combiners. Desirable specific combining ability of the crosses involving such parents seems to be mainly due to complementation of the genes. Thus these crosses can be exploited for grain yield per plant by using biparental mating system

Key words: *Triticum aestivum*, combining ability, yield attributes.

Introduction

Wheat is the world's most important food crop. It ranks first among cereals in production and constitutes the staple food of about 36 per cent of the world population. The major and foremost aspect in increasing production and productivity in wheat is adoption of high yielding, disease resistant, photothermotolerant and fertilizer responsive varieties to exploit various genetically important properties such as particular kind of gene actions, heterosis, desirable associations and heritability of important traits and using effective breeding strategies so as to obtain maximum improvement in the genetic yield potential of wheat. In order to evolve an effective hybridization programme combining ability analysis is used to test the performance of parents in different cross combinations and characterize the nature and magnitude of gene effects in the expression of quantitative traits. Thus, the main objective of the present investigation was to identify the best combining parents and their crosses on the basis of their general and specific combining abilities. The estimates combing ability variance and effect can give indication of the relative magnitude of genetic variance. These also provide a guideline for selecting

elite parents and desirable cross combinations to be used in formulation of system breeding project for rapid improvement.

Material and methods

The present investigation was carried out during the *rabi* 2005 – 06 at the Crop Research Centre of Sardar Vallabh Bhai Patel University of Agriculture and Technology, Modipuram, Meerut.The experimental material for present investigation comprised 36 F_1s along with 15 parents (12 lines and three testers).These materials were evaluated in a completely Randomized Block Design (RBD) with three replications during *rabi* 2005-06. Each of 36 F_1s was planted in one-meter long single row plot and the parents were planted in two rows. The rows were spaced 23 cm apart. The plant-to-plant distance was maintained at 10 cm by proper thinning. The border rows were also planted to neutralize the border effect. Combining ability analysis was carried out following Kempthorne (1957)

Results and discussion

Among various lines, line HD 2687 was identified as a good general combiner for the characters days to heading, days to maturity, plant height and biological yield per plant, whereas, Line UP 2338 appeared as a good general combiner for the characters, plant height, tillers per plant, spikelets per ear, spike length, grains per ear and 1000-grain weight. Line 35th IBWSN-4 for days to maturity and harvest index; Line 35th IBWSN-14 for days to maturity, grains per ear and grain yield per plant; 10th HTWYT-47 for days to heading, days to maturity, tillers per plant and grains per ear; 11th HRWYT-7 for the characters spike length, 1000- grain weight, harvest index and grain yield per plant and 4th IAT-49 for tillers per plant, plant height and harvest index were identified as good general combiners. Lines 20th SAWSN-18, CPAN 3004 and RD 1008 were identified as good general combiners for days to heading, tillers per plant and biological yield per plant, respectively.

The results indicated in Table 1 reveals that the line UP 2338 combines well for the highest number of characters (six) followed by HD 2687,10th HTWYT-47 and 11TH HRWYT-7 with four characters each and the lines 11th HRWYT-3 and 11th HRWYT-16 were good general combiner for none of the characters. Tester PBW 373 emerged as a good general combiner for the characters days to heading and biological yield per plant, whereas, Tester PBW 502 appeared as a good general combiner for the tillers per plant.

The estimates of *gca* effects of the parental lines, including lines and testers, for different characters revealed that none of the parental lines excelled in gca effects either for all the characters studied or at least for all the important yield components studied. This suggested the use of multiple parent participation through multiple crossings to effect substantial improvement in yield and its components. Similar results have been reported by Sharma *et al.* (1978), Kumar *et al.* (1983), Bhullar *et al.* (1988), Nirmal *et al.* (1993) Rajara and Maheshwari (1996) Singh and Singh (2003),Hassani et al.(2005) and Singh *et al.*(2009).

The parents based on high mean performance and highest *gca* effects are presented in Table 2. The *per se* performance of testers showed correspondence with their *gca* effects in case of days to heading, plant height, spike lets per ear, 1000-grain weight and in grain yield per plant. Several workers have suggested that the *per se* performance of parents may be used as basis of selection for identifying the good general combiners for different characters. These results are in conformity with Zubir *et al.* (1987); Raghauvanshi *et al.* (1988); Nirmal *et al.* (1993) and Tosun *et al.* (1995). However, in case of parental lines the best general combiners did not have the highest *per se* mean performance over the character concerned.

Specific combining ability (Table 3) represents the dominance and epistatic types of gene action and it can be related with heterosis. Normally the non-additive gene effect would not contribute tangibly in the improvement of grain yield in self-pollinated crops, except where the commercial exploitation of heterosis is feasible. In self-pollinated crops, however, the additive x additive type of interaction is also fixable in later generations and can be exploited for the improvement of grain yield and related traits.
If crosses showing high *sca* effects involve, parents which are also good general combiners, these crosses could be exploited by simple methods like pedigree selection, provided the additive x additive component of interaction was significant. Out of 36 cross combinations, nine crosses *viz.* UP 2338/ PBW 502 (5.73), 4th IAT-49 / PBW 502 (5.01), 11th HRWYT-16/ PBW 343 (4.84), 10th HTWYT-47/ PBW 343 (4.22), RD 1008/ PBW 373 (4.19), 35th IBWSN-14/ PBW 502 (3.14), 20th SAWSN-18/ PBW 343 (2.90), 35th IBWSN-4/ PBW 502 (2.02) and CPAN 3004/ PBW 373 (1.90) emerged with significant positive *sca* effects for grain yield per plant.

The parents involved in these crosses are average x average general combiners and or poor x average

combiners except in cross 35th IBWSN-14/ PBW 502 (3.14), which involved good x average general combiners. Desirable specific combining ability of the crosses involving such parents seem to be mainly due to complementation of the genes. Thus these crosses can be exploited for grain yield per plant by using biparental mating system as per Joshi and Dhawan (1966).

The crosses 11th HRWYT-16/ PBW 343, RD 1008/ PBW 373, 20th SAWSN-18/ PBW 343 and 35th IBWSN-14/ PBW 502 had high *sca* effects for biological yield per plant and grain yield per plant. Crosses 10th HTWYT-47/ PBW 343 for grains per ear and grain yield per plant; 35th IBWSN-4/ PBW 502 for grain yield per plant and 1000- grain weight; CPAN 3004/ PBW 373 for grains per ear, harvest index and grain yield per plant also had high *sca* effects. All these crosses involve both the parents as average general combiners or one of the parents as good general combiners indicating that non additive type of gene actions, which are unfixable in nature were involved in selected cross combinations.

A close examination of crosses on the basis of best mean performance (Table 4) and *sca* effects revealed that there is close agreement in the performance of cross 11th HRWYT-7/PBW 343 based on their mean performance and highest *sca* value for the characters 1000 grain weight and biological yield per plant. However, for all the other characters studied, the crosses with high *sca* effects were not having high mean values. These findings were supported by Gill (1977), Sheikh and Singh (2000), Josi *et.al.* (2004), Kumar *et al.* (1983); Palve *et al.* (1986) and Thakre *et al.* (1996).

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Table 1: Estimates of general combining ability effects of lines and testers with respect to 11 character of bread wheat

Lines/ Testers	Days to heading	Days to maturity	Plant height (cm)	Tillers/ plant	Spike lets/ ear	Spike length (cm)	Grains/ ear	1000-grain weight(g)	Biological yield/ plant (g)	Grain yield/plant (g)	Harvest Index (%)
HD 2687	-2.22 **	-0.96 *	-3.14**	-0.20	-0.23	0.05	0.80	-0.32	5.82**	-1.40*	-6.92**
UP 2338	0.00	1.03 *	-3.72**	0.60*	0.78 *	0.45 *	6.88 **	2.39 **	1.95	0.39	0.42
20th SAWSN-18	-0.88*	-0.40	4.54 **	-1.73**	0.18	-0.08	-0.84	0.23	2.70	-0.95	-4.29**
35th IBWSN-4	-0.55	-1.40 **	3.91 **	-1.39**	0.27	-0.57**	1.52	-1.60	-3.72*	0.87	4.64**
35th IBWSN-14	-0.33	-0.96 *	1.80	-0.58*	0.03	-0.08	5.93 **	0.39	0.77	1.93**	2.57
10th HTWYT-47	-1.00**	-1.29 **	1.03	1.28**	-0.03	-0.70**	2.28 *	0.06	-0.60	-1.19*	-2.35
CPAN 3004	0.22	-0.18	0.36	0.97**	-0.03	-0.19	0.78	-0.99	-3.71*	-1.52*	0.33
RD 1008	0.22	-0.07	1.96	0.38	-0.14	0.01	-6.73 **	1.34	4.24**	0.76	-1.78
11th HRWYT-3	2.33 **	2.48 **	-1.92	-0.11	0.18	-0.24	-4.84 **	-2.40 **	-2.67	-0.42	1.41
11th HRWYT-7	0.44	1.25 **	-2.68	-0.11	-0.19	0.87 **	-1.84 *	3.25 **	1.94	3.63**	5.66**
11th HRWYT-16	1.00 **	0.70	0.14	-0.29	0.18	0.41	-1.38	-1.88 *	-4.02*	-2.97**	-3.12
4th IAT-49	0.77 *	-0.18	-2.28*	0.62**	-0.99 **	0.09	-2.58 **	-0.49	-2.73	0.87	3.44*
PBW 343	0.33	0.01	-0.29	-0.26*	-0.01	-0.09	0.48	0.33	0.43	0.12	-0.06
PBW 373	-0.36*	0.34	0.20	-0.09	0.09	0.18	-0.29	0.07	1.74*	0.18	-0.79
PBW 502	0.02	-0.35	0.09	0.35**	-0.08	-0.09	-0.18	-0.40	-2.17**	-0.30	0.85
SE [gi] (±)	0.29	0.38	0.95	0.18	0.25	0.17	0.72	0.62	1.26	0.44	1.29
SE [gj] (±)	0.13	0.16	0.40	0.08	0.11	0.07	0.31	0.27	0.54	0.19	0.55
SE [gi-gj] (±)	0.52	0.67	1.66	0.32	0.43	0.29	1.27	1.09	2.21	0.76	2.25
SE [gi-gj] (±)	0.26	0.33	0.83	0.16	0.21	0.14	0.63	0.54	1.10	0.38	1.12

* significant at 5 % probability level ** significant at 1 % probability level

Table 2: Summary table for general combining ability of parents for different characters

Characters Parents	Days to heading	Days to maturity	Plant height	Tillers /plant	spikelets/ear	Spike length	Grains /ear	1000-grain weight	Biological yield/plant	Grain yield /plant	Harvest index
Line											
HD 2687	G	G	G	A	A	A	A	A	G	P	P
UP 2338	P	P	G	G	G	G	G	G	A	A	A
20th SAWSN-18	G	A	P	P	A	A	A	A	A	A	P
35th IBWSN-4	A	G	P	P	A	P	A	A	P	A	G
35th IBWSN-14	A	G	A	P	A	A	G	A	A	G	A
10th HTWYT-47	G	G	A	G	A	P	G	A	A	P	A
CPAN – 3004	A	A	A	G	A	A	A	A	P	P	A
RD 1008	A	A	A	A	A	A	P	A	G	A	A
11th HRWYT- 3	P	P	A	A	A	A	P	P	A	A	A
11th HRWYT- 7	A	P	A	A	A	G	P	G	A	G	G
11th HRWYT-16	A	A	A	A	A	A	A	P	P	P	A
4th IAT-49	P	A	G	G	G	A	P	A	A	A	G
Tester											
PBW – 343	A	A	A	P	P	A	A	A	A	A	A
PBW – 573	G	A	A	A	A	A	A	A	G	A	A
PBW – 502	A	A	A	G	G	A	A	A	P	A	A

A = Average gca, P = Poor gca, G = Good gca

Table 3: Estimates of specific combining ability effects with respect to 11 characters in common wheat

Lines	Tillers/ plant			Grains/ ear			1000-grain weight (g)		
	PBW-343	PBW-373	PBW-502	PBW-343	PBW-373	PBW-502	PBW-343	PBW-373	PBW-502
HD 2687	0.03	-0.27	0.23	-2.05	0.30	1.74	2.77*	-1.79	-0.98
UP 2338	-1.90**	2.33**	-0.44	1.02	0.77	-1.80	-0.94	0.48	0.46
20th SAWSN-18	-0.03	-0.80*	0.83*	-1.63	0.86	0.76	-0.78	1.15	-0.37
35th IBWSN-4	-0.44	0.46	-0.01	-2.22	1.66	0.55	-5.44**	0.65	4.79**
35th IBWSN-14	0.01	0.18	-0.19	-0.77	1.08	-0.31	1.38	0.15	-1.53
10th HTWYT-47	-1.11**	0.86*	0.25	3.12*	-5.59**	2.46	-0.78	0.65	0.13
CPAN 3004	0.00	-0.30	0.30	0.62	4.40*	-5.03**	0.10	-0.29	0.18
RD 1008	0.59	0.29	-0.88*	-0.52	-3.29	3.81*	0.77	1.54	-2.31
11th HRWYT-3	0.15	-0.62	0.48	-4.07*	2.14	1.92	0.11	1.78	-1.90
11th HRWYT-7	1.41**	-1.82**	0.41	6.76**	-2.29	-4.46**	3.03*	-3.63**	0.60
11th HRWYT-16	0.28	0.25	-0.52	-1.43	-1.00	2.43	1.83	-1.40	-0.42
4th IAT-49	1.01*	-0.55	-0.46	1.16	0.93	-2.10	-2.05	0.70	1.35
Sij	0.55			1.55			0.38		
Sij- Skl	0.92			2.20			1.90		

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

	Biological yield/plant (g)			Grain yield /plant (g)			Harvest index (%)		
	PBW-343	PBW-373	PBW-502	PBW-343	PBW-373	PBW-502	PBW-343	PBW-373	PBW-502
HD 2687	3.02	-6.20*	3.18	-0.13	0.53	-0.39	-2.08	4.92	-2.84
UP 2338	-19.87**	15.82**	4.06	-5.90**	0.17	5.73**	4.80	-10.51**	5.71*
20th SAWSN-18	6.44*	-1.93	-4.51	2.90**	-0.90	-2.00*	0.66	-0.42	-0.25
35th IBWSN-4	-2.83	0.50	2.34	-2.59**	0.57	2.02*	-2.80	0.04	2.76
35th IBWSN-14	-6.02*	-0.88	6.91*	-0.86	-2.28**	3.14**	3.52	-3.61	0.09
10th HTWYT-47	3.54	7.80**	-11.34**	4.22**	1.67	-5.89**	4.94	-2.47	-2.47
CPAN 3004	-2.31	-3.58	5.88*	0.08	1.90*	-1.99*	1.30	6.41*	-7.71**
RD 1008	-4.29	11.76**	-7.46**	-1.69	4.19**	-2.50**	0.23	-1.42	1.19
11th HRWYT-3	3.09	-1.48	-1.61	1.46	0.16	-1.62	0.36	1.49	-1.85
11th HRWYT-7	9.97**	-9.94**	-0.03	-0.93	-0.04	0.97	-9.79**	8.17**	1.62
11th HRWYT-16	5.66*	-6.13*	0.47	4.84**	-2.36**	-2.48**	4.61	0.03	-4.64
4th IAT-49	3.61	-5.73*	2.12	-1.40	-3.60**	5.01**	-5.75*	-2.64	8.39**
Sij	2.70			0.93			1.82		
Sij- Skl	3.82			1.32			6.73		

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

Table 4: Parental lines with the highest mean and general combining ability effects together with crosses with highest mean and *sca* effects

Characters		Parents		Crosses	
		Highest mean	High *gca*	Highest mean	High *sca*
Days to heading	Line	11th HRWYT –7	HD 2687	11thHRWYT-3 /PBW 343	–
	Tester	PBW 373	PBW 373		
Days to maturity	Line	UP 2338	35th IBWSN-4	11th HRWYT-3 /PBW343	–
	Tester	PBW 343	PBW 502		
Plant height	Line	20th SAWSN-18	UP 2338	20thSAWSN-18/PBW343	–
	Tester	PBW 343	PBW 343		
Tillers per plant	Line	20th SAWSN-18	10th HTWYT-47	4th IAT-49/ PBW 343	UP 2338/ PBW 343
	Tester	PBW 373	PBW 502		
Spikelets /ear	Line	10th HTWYT-47	UP 2338	CPAN – 3004/ PBW 343	–
	Tester	PBW 373	PBW 373		
Spike length	Line	4th IAT-49	11th HRWYT- 7	11th HRWYT-7/PBW 343	–
	Tester	PBW 343	PBW 373		
Grains per ear	Line	CPAN – 3004	UP 2338	UP 2338/ PBW 343	11th HRWYT- 7/ PBW 343
	Tester	PBW 502	PBW 343		
1000-grain weight	Line	HD 2687	11th HRWYT- 7	11th HRWYT-7/PBW 343	11th HRWYT- 7/ PBW 343
	Tester	PBW 343	PBW 343		
Biological yield /plant	Line	35th IBWSN-14	HD 2687	11th HRWYT-7/PBW 343	11th HRWYT- 7/ PBW 343
	Tester	PBW 502	PBW 373		
Grain yield / plant	Line	RD 1008	11th HRWYT- 7	10thHTWYT-47/PBW343	11th HRWYT-16/ PBW 502
	Tester	PBW 373	PBW 373		
Harvest index (%)	Line	4th IAT-49	11th HRWYT- 7	35th IBWSN-14/PBW343	CPAN – 3004/ PBW 373
	Tester	PBW 373	PBW 502		