Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(6): 1717-1722
Received: 10-09-2020
Accepted: 17-10-2020

Pawan Kumar Saini
Student, Department of Genetics and Plant Breeding, Section of Rabi Cereals, CSA University of Agriculture & Technology Kanpur, Uttar Pradesh, India

Sarvendra Kumar
Professor, CSA University of Agriculture & Technology Kanpur, Uttar Pradesh, India

Som Veer Singh
Assistant Professor/ Wheat Breeder, Section of Rabi Cereals, CSA University of Agriculture & Technology Kanpur, Uttar Pradesh, India

Corresponding Author:
Pawan Kumar Saini
Student, Department of Genetics and Plant Breeding, CSA University of Agriculture & Technology Kanpur, Uttar Pradesh, India

Combining ability analysis of F_1 generation in bread wheat (*Triticum aestivum* L.)

Pawan Kumar Saini, Sarvendra Kumar and Som Veer Singh

Abstract
Wheat is an edible grain, one of the oldest and most important of the cereal crops in the world. Eight diverse genotypes were crossed in diallel mating design excluding reciprocals for studying of combining ability analysis in F_1 generation of wheat at Crop Research Farm, Nawabganj of C. S. A. University of Agriculture and Technology, Kanpur-208002 UP India. The genotypes under study were planted in a randomized complete block design (RCBD). Highly significant variances for both general and specific combining abilities for all the characters studied were found which indicated the importance of both additive and non-additive gene effects. On the basis of GCA effect the good parents were namely, K7903 for seven characters, K307 for six characters, HD 3171 for six characters, PBW502 for six characters, WH147 for five characters, K1006 for five characters, DBW14 for five characters and K906 for two characters. On the basis of SCA effects top five superior combinations in order to merit were observed for *viz*, WH147 X PBW502 in respects to days to 75% heading, number of spikelets per spike, number of grains per spike, biological yield per plant and grain yield per plant. In order to merit were K7903 X DBW14 for days to 75% heading, plant height, number of grains per spike, biological yield per plant and grain yield per plant. In order to merit were HD3171 X WH147 for days of maturity, number of spikelets per spike, spike length and weight of grains per spike. In order to merit were HD3171 X K906 for days to maturity, number of spikelet per spike and harvest index. In order to merit were HD3171 X K906 for days of maturity, number of spikelets per spike, harvest index.

Keywords: wheat, diallel, combining ability, GCA and SCA.

Introduction
Wheat is an edible grain, one of the oldest and most important of the cereal crops in the world. It is one of the most important cereal crops both in regard to its antiquity and its use as a source of human food. It is a major staple food crop of the world after rice. Extensive references are made to wheat in ancient Indian scriptures. Atharva-Veda which supposed to have been written between 1500 B.C. and 500 B.C. refers to the grain of wheat. The centre of origin of wheat is Asia Minor. Wheat (*Triticum aestivum* L.) is belonging to poaceae family presently. Bread wheat is an allohexaploid (AABBDD). The major wheat growing countries in the world are China, India, U.S.A., Russia, France, Canada, Germany, Turkey, Australia and Ukraine. Nearly 55 per cent of the world population depends on wheat for intake of about 20 per cent of food calories. Globally, wheat is being grown in 122 countries and occupies an area of 214.29 million hectares producing nearly 734.04 million tonnes and yield per hectare 3.425 metric tonnes (USDA 2018). At national level area under wheat is 29.58 million ha with the production of 99.70 million tonnes with a productivity of 3.371metric tonnes per hectare (DACFW 2018). Wheat contributed about 34% of total food grain production of country. India stands second rank both in area and production next to China in the world. The India's share in world wheat area and production is about 13%. Thus, India has enabled not only to be self sufficient in wheat food grains but also to export on limited scale to needy and friendly countries. Wheat demands for food (65%), animal feed (17%) industrial applications (12%) and miscellaneous (6%) (FAO statistical year book 2013).In view for its unsatisfying availability of desirable genotypes with good quality and better yield, it is therefore, the ultimate goal of plant breeders to develop desirable genotypes due to the climate change environment. To continue supplying of wheat an efficient breeding program for development of superior genotypes, it is also essential to understand the mode of inheritance, the magnitude of gene effects and its inheritance in next generation. Identification of genetically superior parents is an important stipulation for developing promising strains. Combining ability analysis provides useful information to select the suitable parents for a hybridizing programme and select the superior crosses. Therefore, the present investigation was undertaken to study the effects of general and specific combining ability for yield and yield contributing traits in wheat.

Materials and Methods

The field experiments of wheat crop were conducted in two cropping season as first Rabi season 2016-17 and second Rabi season 2017-18 at locations, namely Crop Research Farm, Nawabganj of C. S. A. University of Agriculture and Technology, Kanpur-208002 UP India. The experimental material for present investigation comprised of 28 F'$_1$s developed by crossing 8 lines *viz*., HD3171, WH147, K906, K307, K1006, K7903, DBW14, and PBW502 following half diallel mating design. A total of 36 treatments (28 F_1's and 8 parents) were used for the study of combining ability and heterosis in F_1 generation for twelve characters in bread wheat. The genotypes under study were planted in a randomized complete block design (RCBD) with three replications per entry and one row (3m) per replication. The entries were sown in a single row plot of 3 m length with inter and intra-row spacing of 25 cm and 10 cm, respectively. Recommended agronomic practices were adopted to raise a good crop. The observations were recorded from the five randomly selected plants in parents and their F1s for all the following traits *viz*. days to 75% heading, number of tillers/plant, plant height (cm), days to maturity, length of spike (cm), number of spikelet/spike, number of grain/spike, grain yield/plant (g), weight of grain per spike (g), 1000 seed weight (g), biological yield/plant (g) and harvest index %. The salient features of these parental lines are given in Table-1.

Table 1: Details of genotypes

S. No.	Genotype	Species	Pedigree	Place of origin
1	HD 3171	*T. aestivum*	PBW 343/HD 2879	IARI,New Delhi
2	WH 147	*T. aestivum*	PJSIB/P14/KT54B/3/C286/C273/4/S339/PV18	HAU, Haryana
3	K 906	*T. aestivum*	UP2338/PBW373	CSA, Kanpur
4	K 307	*T. aestivum*	K 9321/UP 2003	CSA, Kanpur
5	K 1006	*T. aestivum*	PBW 343/HP 1731	CSA, Kanpur
6	K 7903	*T. aestivum*	HD 1982/K 816	CSA, Kanpur
7	DBW 14	*T. aestivum*	RAJ 3765/PBW 343	IIWBR, Karnal
8	PBW 502	*T. aestivum*	W 485/PBW 343//RAJ 1482	PAU, Punjab

Result and Discussion

The analysis of variance for all the twelve characters was given in table-2. The treatments showed highly significant differences for all the characters. The parents indicated highly significant differences for all the characters except harvest index. F_1S indicated highly significant differences for all the characters. The comparison of parents *vs* F_1 generation indicated significant for plant height and highly significant differences for days to heading, days to maturity, number of tillers per plant, number of spikelets per spike, number of grains per spike, grain yield per plant and biological yield per plant while non significant differences were found for spike length, grain weight per spike, 1000 grain weight and harvest index.

Table 2: Analysis of variance (ANOVA) for combining ability for twelve traits in diallel Crosses in Bread wheat

Source of variance	d.f.	Days to Heading (75%)	Plant height (cm)	Days to maturity	No. of tillers/ plant	No. of spikelets / spike	Spike length (cm)	No. of grains/ spike	1000 grain weight (g)	Grain weight/spike (g)	Biological yield/plant (g)	Grain yield / plant (g)	Harvest index %
GCA	7	25.27**	78.79**	27.71**	1.67**	3.49**	3.69**	4.89**	10.46**	0.09**	216.18**	28.77**	8.89**
SCA	28	12.26**	17.41**	7.12**	2.22**	1.21**	0.34**	9.91**	4.72**	0.04**	36.24**	6.45**	11.37**
Error	70	0.92	1.96	0.23	0.31	0.13	0.02	0.51	2.02	0.01	1.26	0.71	0.45
$\delta^2 g$	-	2.43	7.68	2.74	0.13	0.33	0.36	0.43	0.84	0.00	21.49	2.80	0.84
$\delta^2 s$	-	11.34	15.44	6.89	1.91	1.07	0.32	9.40	2.70	0.03	34.98	5.74	10.92
$\delta^2 g/ \delta^2 s$	-	0.21	0.49	0.39	0.07	0.31	1.12	0.04	0.31	0.00	0.61	0.48	0.07
$(\delta^2 s/ \delta^2 g)^{0.5}$	-	2.16	1.41	1.58	3.83	2.86	0.94	4.67	3.54	0.00	1.27	1.43	3.60

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

GCA= General combining ability; SCA = specific combining ability; degree of dominance. $(\delta^2 s/ \delta^2 g)^{0.5}$ = Ratio of GCA variance to SCA variance;

Combining ability analysis

(A) General combining ability (GCA) effect:-The estimates of GCA effect of eight parents for all the twelve characters are presented in Table-3. The consideration of mean performance and GCA effect with positive and significant, positive non-significant and negative significant results obtained are described under as here (1) Days to 75% heading the range of GCA effect varied from K7903 (-2.67) to K1006 (1.69). Negative significant GCA effect was showed by K7903 (-2.67) and WH147 (-1.84) and found good general combiners (2) Days to maturity the values of GCA effect ranged from K7903 (-3.06) to WH147 (1.90). Out of eight parents only two parents namely genotypes K7903 (-3.06) and DBW14 (-0.86) were showed negative and significant GCA effect and indicate the good general combiners for this character. (3) Plant height (cm) for the value of GCA effect ranged from K7903 (-3.42) to HD3171 (5.34). Out of eight parents only three parents namely, WH147 (-2.39), K906 (-2.59) and K7903 (-3.42) were showed negative and significant GCA effects and proved to be as good general combiners. (4) Number of tillers per plant the values of GCA effect varied from DBW14 (-0.03) to WH 147 (0.34). The genotypes *viz*, WH147 (0.34) and K7903 (0.34) were showed positive and significant GCA effects and indicating that their ability as good general combiners. (5) Spike length (cm) the values of GCA effects for this trait varied from K7903 (-0.64) to HD3171 (1.20). The genotypes *viz*, HD3171 (1.20), K307 (0.44) and K1006 (0.25) showed positive and significant GCA effects and indicating that their ability as good general combiners for this character. (6) Number of spikelets per spike the values of GCA effects for number of spikelets per spike ranged between WH147 (-0.79) to K307 (0.89).The genotypes *viz.* HD3171 (0.66), K307 (0.89) and K1006 (0.32) showed positive and significant for GCA effects and

indicating that their ability good general combiners for this character. (7) Number of grains per main spike the values for GCA effect varied form K307 (-0.98) to K1006 (1.20) for number of grain per spike. The genotypes *viz* K1006 (1.20) and DBW14 (0.43) showed positive and significant for GCA effect and indicating that their ability good general combiners for this character.(8)1000 grain weight (g) the values of GCA effects of 1000-grain weight varied from PBW502 (-0.75) to DBW14 (1.65). The genotypes *viz* WH147 (0.93) and DBW14 (1.65) showed positive and significant GCA effects and indicating that their ability as good general combiners for this character. (9) Grains weight per spike (g) the values of GCA effect for grain weight per spike ranged from WH147 (-0.20) to K7903 (0.06). The genotypes *viz*, HD3171 (0.09), K7903 (0.06) and DBW14 (0.06) showed positive and significant GCA effects and indicating that their ability as good general combiners for this character. (10) Biological yield per plant the value of GCA effect for biological yield ranged from K906 (-5.08) to HD3171 (8.01). The genotypes *viz* HD3171 (8.01), K307 (5.03) and PBW502 (1.45) showed positive and significant GCA effects and indicating that their ability as good general combiners for this character. (11) Grain yield per plant the values of GCA effect for grain yield per plant ranged from K906 (-2.00) to HD3171 (3.02). The genotypes *viz* HD3171 (3.02) K307 (1.70) and PBW502 (0.58) showed positive and significant GCA effects indicating that their ability as good general combiners for this character. (12) Harvest index (%) the value of GCA effect for harvest index ranged from DBW14 (-1.26) to K1006 (1.93). The genotypes *viz* K1006 (1.93) and PBW502 (0.48) showed positive and significant for GCA effect and indicating that their ability good general combiners for this character.

Table 3: Estimates of GCA effects of parents for twelve traits in diallel crosses in bread wheat

Source of variance	Days to Heading (75%)	Plant height (cm)	Days to maturity	No. of tillers/ plant	No. of spikelets/spike	Spike length (cm)	No. of grains/ spike	1000 grain weight (g)	Grain weight /spike (g)	Biological yield /plant(g)	Grain yield/ plant (g)	Harvest index %
HD3171	-0.24	5.34**	0.13	-0.68**	0.66**	1.20**	0.12	-0.56**	0.09**	8.01**	3.02**	-0.54**
WH147	-1.84**	-2.39**	1.90**	0.34*	-0.79**	-0.51**	0.09	0.93*	-0.20**	-0.92**	-0.80**	-0.00
K906	1.42**	-2.59**	0.70**	-0.55**	-0.39**	-0.22**	-0.77**	-0.33	0.02	-5.08**	-2.00**	-0.34
K307	1.29**	0.91*	1.43**	0.30	0.89**	0.44**	-0.98**	0.19	-0.07*	5.03**	1.70**	-0.43*
K1006	1.69**	0.88*	0.53**	0.02	0.32**	0.25**	1.20**	-0.58	-0.01	-3.44**	-0.16	1.93**
K7903	-2.67**	-3.42**	-3.06**	0.34*	-0.53**	-0.64**	-0.34	0.46	0.06*	-4.55**	-1.53**	0.17
DBW14	-0.30	0.67	-1.86**	-0.03	-0.01	-0.33**	0.43*	1.65**	0.06*	-0.48	-0.81**	-1.26**
PBW502	0.65*	0.59	0.23	0.26	-0.14	-0.18**	0.23	-0.75	0.04	1.45**	0.58*	0.48*
SE(gi)	0.67	0.98	0.33	0.39	0.26	0.10	0.50	0.99	0.07	0.78	0.59	0.47

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

(B) Specific Combining ability (SCA) effect: The estimates of specific combining ability (SCA) and their effect in F_1s for twelve characters yield and its attributes are presented in Table-4. The results for various characters are described as under (1) Days to 75%heading the SCA effect for days to 75% heading varied from K7903xDBW14 (-4.28) to DBW14xPBW502 (7.38) in F_1 generation. Five crosses out of twenty eight crosses exhibited negative and significant SCA effect with good specific combinations *viz*, K7903xDBW14, WH147xK307, HD3171xK7903, HD3171xK906 and WH147xPBW502 in F_1 generation. (2) Days to maturity the value of SCA effect for days to maturity ranged from HD3171xWH147 (-4.73) to HD3171xK7903 (4.56) in F_1 generation. Out of twenty eight crosses nine cross combinations showed negative and significant with good specific combiners *viz*, HD3171xWH147, HD3171xK906, HD3171xK307, WH147xK306, K906xK307, K906xK1006, K1006xPBW502, K790xPBW502 and DBW 14xPBW 502. (3) Plant height (cm) in F_1 generation, the range of SCA effect were found between K7903xPBW502 (-6.62) to DBW14xPBW502 (6.91).The first three crosses in order of merit K7903xPBW502, K906xPBW502 and WH147xK7903 with good specific combiners. (4)Number of tillers per plants the values of SCA effect for number of tillers per plants varied from HD3171xDBW14 (-2.43) to DBW14xPBW502 (2.35) in F_1 generation. Two cross combination showed highly positive and significant SCA effect i.e. WH147xK7903 and DBW14xPBW502. (5) Spike length (cm) the values of SCA effect varied from K906xK307 (-1.25) to K1006xK7903 (0.79) in F_1 progeny for spike length. The top three good cross combinations were K1006xK7903, K307xPBW502 and HD3171xWH147 with good specific combiners. (6)Number of spikelets per spike the cross combinations ranged from K307xPBW502 (-1.95) to WH147xPBW502 (1.73) for SCA effect in F_1 generation. The top three cross combinations were WH147xPBW502, DBW14xPBW502 and HD3171xK906 with good specific combiners. (7) Number of grains per main spike the values of SCA effect for number of grains per main spike ranged from K1006xDBW14 (-4.61) to K906xK1006 (6.29) in F_1 progeny. The three cross combinations were K906xK1006, HD3171xDBW14 and K7903xDBW14 with good specific combiners.(8)1000 grain Weight (g) the range of SCA effect varied from K906xK307 (-4.51) to WH147xK1006 (5.66). Top three cross combination were WH147xK1006, DBW14xPBW502 and K307xK1006. (9) Grains weight per spike (g) the range of SCA effect varied from WH147xK7903 (-0.41) to HD3171xWH147 (0.37) for grain yield per plant. The three cross combinations were HD3171xWH147, K906xK307 and K307xK7903 with good specific combiners. (10)Biological yield (g) the range of SCA effect varied from K1006xPBW502 (-10.89) to K1006xK7903 (9.8) for biological yield per plant. The three cross combinations were K1006xK7903, WH147xDBW14 and WH147xPBW502 with good specific combiners.(11) Grain yield per plant (g) the range of SCA effect varied from K1006xPBW502 (-5.35) to K307xK1006 (4.98) for grain yield per plant. The three cross combinations were K307xK1006, K7903xDBW14 and WH147xPBW502 with good specific combiners.(12) Harvest index (%) the range of SCA effect varied from K307xDBW14 (-5.55) to K1006xDBW14 (7.25) for harvest index per plant. The three cross combinations were K307xK1006, HD3171xK906 and K7903xPBW502 with good specific combiners.

Table 4: Estimates of SCA effects and per se performance of 28 F_1s for twelve traits in diallel cross in bread wheat.

Crosses	Days to Heading75%		Plant height (cm)		Days to maturity		No. of tillers / plant		No. of spikelets /spike		Spike length (cm)	
	SCA	Per se	SCA	Per se	SCA	Per se	SCA	Per se	SCA	Per se	SCA	Per se
HD3171 X WH147	4.48**	81.00	5.06**	97.20	-4.73**	120.33	0.35	14.43	1.13**	19.73	0.64**	10.73
HD3171 X K906	-2.11*	77.66	6.26**	98.20	-2.87**	121.00	-0.77	12.40	1.19**	20.20	0.31*	10.70
HD3171 X K307	-1.98*	77.66	0.08	95.53	-3.60**	121.00	-1.83**	12.20	-1.42**	18.86	-0.24	10.80
HD3171 X K1006	2.28*	82.33	0.18	95.60	0.96*	124.66	-1.02	12.73	-0.06	19.66	-0.05	10.80
HD3171 X K7903	3.64**	79.33	5.29**	96.40	4.56**	124.66	-1.80**	12.26	0.46	19.33	0.74**	10.70
HD3171 X DBW14	1.61	79.66	-1.83	93.36	0.03	121.33	-2.43**	11.26	-0.38	19.00	0.56**	10.83
HD3171 X PBW502	2.31*	81.33	-0.34	94.77	1.59**	125.00	0.14	14.13	0.67	19.83	0.18	10.60
WH147 X K906	0.81	79.00	4.29**	88.50	-1.30**	124.33	-0.53	13.66	-0.67	16.86	0.03	8.70
WH147 X K307	-3.38**	74.66	-1.44	86.26	1.96**	128.33	-0.72	14.33	-1.16**	17.66	-0.79**	8.53
WH147 X K1006	1.88*	80.33	-0.67	87.00	2.86**	128.33	0.41	15.20	-1.86**	16.40	-0.54**	8.60
WH147 X K7903	3.91**	78.00	-5.17**	78.20	2.46**	124.33	2.03**	17.13	-0.07	17.33	0.25	8.50
WH147 X DBW14	-0.45	76.00	-2.13	85.33	1.59**	124.66	0.87	15.60	-0.39	17.53	-0.18	8.36
WH147 XPBW502	-2.75**	74.66	-2.58	84.80	-0.50	124.66	0.84	15.86	1.73**	19.53	-0.00	8.70
K906 X K307	-0.98	80.33	-3.84**	83.66	-1.50**	123.66	1.31*	15.46	-0.30	18.93	-1.25**	8.36
K906 X K1006	-0.38	81.33	-2.67*	84.80	-0.93*	123.33	-1.08*	12.80	-0.53	18.13	-0.79**	8.63
K906 X K7903	1.64	79.00	1.89	85.06	3.33**	124.00	-0.12	14.06	-0.34	17.46	-0.06	8.46
K906 X DBW14	0.28	80.00	-4.33**	82.93	4.46**	126.33	-1.28*	12.53	0.07	18.40	-0.10	8.73
K906 X PBW502	-0.35	80.33	-6.52**	80.66	1.03*	125.00	-1.84**	12.26	-0.32	17.86	0.37**	9.36
K307 X K1006	0.41	82.00	0.01	91.00	2.99**	128.00	0.72	15.46	-0.09	19.86	0.03	10.13
K307 X K7903	5.44**	82.66	1.91	88.60	-0.40	121.00	-1.65**	13.40	-0.50	18.60	0.17	9.36
K307 X DBW14	0.41	80.00	-2.84*	87.93	2.39**	125.00	0.58	15.26	-0.22	19.40	0.53**	10.03
K307 X PBW 502	1.11	81.66	1.50	92.20	-0.03	124.66	0.15	15.16	-1.95**	17.53	0.64**	10.30
K1006 X K7903	3.71**	81.33	3.35*	90.00	-0.83	119.66	0.04	14.73	0.13	18.66	0.79**	9.80
K1006 X DBW 14	0.34	80.33	1.45	92.20	-0.70	121.00	0.32	14.73	-0.38	18.66	0.48**	9.80
K1006 X PBW 502	1.04	82.00	-1.46	89.20	-2.80**	121.00	0.16	14.86	-0.58	18.33	0.16	9.63
K7903 X DBW14	-4.28**	71.33	-4.43**	82.00	-0.10	118.00	0.94	15.66	-0.06	18.13	-0.74**	7.66
K7903 X PBW 502	-0.25	76.33	-6.62**	79.73	-3.87**	116.33	0.18	15.20	0.67	18.73	-0.73**	7.83
DBW 14 XPBW502	7.38**	86.33	6.91**	97.36	-1.07*	120.33	2.35**	17.00	1.21**	19.80	-0.24	8.63
SE(Sij)±5%	1.78		2.61		0.89		1.03		0.69		0.26	
SE(Sij)±1%	2.41		3.52		1.20		1.40		0.93		0.35	

Table 5: Ranking top three desirable parents based on GCA effect and per se performance for twelve traits in bread wheat.

Traits	Good general combiners based on GCA effect	Desirable parents on the basis of per se performance	Common parents based on GCA and per se performance
Days to heading	K7903	K7903	K7903
	WH147	WH147	WH147
	DBW14	HD3171	-
Plant height(cm)	K7903	K7903	K7903
	K906	WH147	WH147
	WH147	K906	K906
Days to maturity	K7903	K7903	K7903
	DBW14	DBW14	DBW14
	-	K1006	-
No. of tillers/plant	WH147	HD3171	K307
	K7903	K307	-
	K307	K906	-
No. of spikelets/spike	K307	K307	K307
	HD3171	K1006	HD3171
	K1006	HD3171	K1006
Spike length(cm)	HD3171	HD3171	HD3171
	K307	K307	K307
	K1006	K1006	K1006
No. of grains/spike	K1006	K1006	K1006
	DBW14	DBW14	DBW14
	PBW502	PBW502	PBW502
1000 grain weight(g)	DBW14	K307	WH147
	WH147	WH147	K7903
	K7903	K7903	-
Weight of grain / spike(g)	HD3171	DBW14	K7903
	K7903	K7903	DBW14
	DBW14	K906	-
Biological yield/plant(g)	HD3171	HD3171	HD3171
	K307	K307	K307
	PBW502	PBW502	PBW502
Grain yield/plant(g)	HD3171	HD3171	HD3171

	K307	K307	K307
	PBW502	PBW502	PBW502
Harvest Index %	K1006	WH147	K7903
	PBW502	K7903	-
	K7903	K906	-

Table 6: Ranking top three desirable combinations based on SCA effect and per se performance for twelve traits in bread wheat.

Traits	Good specific combiners based on SCA effect	Superior crosses on the basis of per se performance
Days to heading	K7903 X DBW14	K7903 X DBW14
	WH147 X K307	WH147 X PBW 502
	WH147 X PBW502	WH147 X K307
Plant height(cm)	K7903 X PBW502	WH147 X K7903
	K906 X PBW502	K7903 X PBW502
	WH147 X K7903	K906 X PBW502
Days to maturity	HD3171X WH147	K7903 X PBW502
	K7903 X PBW502	K7903 X DBW14
	HD3171 X K906	K1006 X K7903
No. of tillers / plant	DBW14 X PBW502	WH147 X K7903
	WH147 X K7903	DBW14 X PBW502
	K906 X K307	WH147 X PBW502
No. of spikelets/ spike	WH147 X PBW502	HD3171 X K906
	DBW14 X PBW502	HD3171 X PBW502
	HD3171 X K906	K307 X K1006
Spike length (cm)	K1006 X K7903	HD3171 X DBW14
	K307 X PBW502	HD3171 X K1006
	HD3171 X WH147	HD3171 X K307
No. of grains/spike	K906 X K1006	HD3171 X DBW14
	HD3171 X DBW14	K906 X K1006
	K7903 X DBW14	K7903 X DBW14
1000 grain weight(g)	WH147 X K1006	WH147 X K1006
	DBW 14 X PBW502	DBW14 X PBW 502
	K307 X K1006	K7903 X DBW14
Weight of grain / spike(g)	HD3171 X WH147	K307 X K7903
	K906 X K307	K906 X K307
	K307 X K7903	K7903 X DBW14
Biological yield/plant (g)	K1006 X K7903	HD3171 X DBW14
	WH147 X DBW14	HD3171 X K1006
	WH147 X PBW502	HD3171 X PBW502
Grain yield /plant(g)	K307 X K1006	K307 X K1006
	K7903 X DBW14	HD3171 X K1006
	WH147 X PBW 502	HD3171 X PBW 502
Harvest Index %	K307 X K1006	K1006 X DBW 14
	HD3171 X K906	K307 X K1006
	K7903 X PBW502	K7903 X PBW502

Conclusion

Highly significant variances for both general and specific combining abilities for all the characters were found which indicated the importance of both additive and non-additive gene effects. The values of GCA and SCA ratio estimates were observed less than unity for all traits except spike length. On the basis of GCA effect the good parents were K7903 for six characters namely, days to heading, plant height, days to maturity, 1000 grain weight, weight of grain per spike and harvest index, K307 for five characters namely, number of tillers per plant, number of spikelets per spike, spike length, biological yield per plant and grain yield per plant, HD3171 for four characters namely, number of spikelets per spike, spike length, biological yield per plant and grain yield per plant, WH147 for three characters namely, days to heading, plant height and 1000 grain weight, PBW502 for three characters namely, number of grain per spike, biological yield per plant and grain yield per plant, K1006 for three characters namely, number of spikelets per spike, spike length and number of grain per spike, DBW14 for three characters namely, days to maturity, number of grain per spike and weight of grain per spike observed and followed by K906 common for only one character. On the basis of SCA effects top five superior combinations in order of merit for various traits namely WH147xPBW502 for days to 75% heading, number of spikelets per spike, biological yield per plant and grain yield per plant, K7903xDBW14 for days 75% heading, number of grains per spike and grain yield per plant, HD3171xWH147 for days of maturity, spike length, weight of grains per spike, HD3171xK906 for days to maturity, number of spikelet per spike and harvest index and WH147xK7903 for plant height and number of tillers per plant. The three good cross combination on the basis of per se performance and specific combining ability were identified namely, K7903xPBW502 for plant height, days to maturity and harvest index, K7903xDBW14 for days to heading and grains per spike, WH147xK7903 for plant height and number tillers per plant.

Acknowledgement

The author, Pawan Kumar Saini, is thankful to Dr (Prof.) Sarvendra Kumar for his support in my research programmed and Dr. S. V. Singh for the support in the execution of the experiments and sample analyses at CSAUA&T Kanpur-

208002 UP India, for their valuable support and guidance throughout the my research programme.

Reference

1. Akhter S, Khan AS, Ihsan K, Rashid A. Combining ability studies on yield related traits in wheat under normal and water stress conditions. Pakistan J of Agri. Sci 2010;47(4):345-354.
2. Baric M, Jercic IH, Keresa S, Sarcevic H. Assessment of heterosis for important quantitative properties in crossings of winter wheat (*Triticum aestivum* L.). Sjemenarstvo 2008;25(1):5-12.
3. Desale CS, Mehata DR. Heterosis and combining ability analysis for grain yield and quality traits in bread wheat (*Triticum aestivum* L.). Electronic J of pl. br. 2013;4(3):1205-1213.
4. Dhananjay, Singh BN, Shekhar R, Bhushan B, Rahul VP. Genetic Variability in Wheat (*Triticum aestivum* L.) under Normal and Timely Sown Condition. Environment & Eco 2012;30(3C):1085-1087.
5. El-Mohsen AAA, Hegazy SRA, Taha MH. Genotypic and phenotypic interrelationship among yield and yield components in Egyptian bread wheat genotypes. Journal of Pl. Br. & Crop Sci 2012;4(1):9-16.
6. Ezgi Yazici, Oğuz Bilgin. Heritability estimates for milling quality associations of bread wheat in the northwest turkey. Int J Res Agron 2019;2(2):17-22. DOI: 10.33545/2618060X.2019.v2.i2a.18
7. Krystkowiak K, Adamski T, Surma M, Kaczmarek Z. Relationship between phenotype and genetic diversity of parental genotypes and the specific combining ability and heterosis effects in wheat (*Triticum aestivum* L). Euphytica 2009;165(3):419-434.
8. Kumar V, Maloo SR. Heterosis and combining ability studies for yield components and grain protein content in bread wheat (*Triticum aestivum* L.). Indian J. of Genet 2011;71(4):363-366.
9. Kumar A, Mishra VK, Vyas RP, Singh V. Heterosis and combining ability analysis in bread wheat (*Triticum aestivum* L.). Journal of Pl. Bre. and Crop Sci 2011;3(10):209-217.
10. Meena HS, Kumar D, Prasad SR. Genetic variability and character association in bread wheat (*Triticum aestivam*). Indian J. of Agri. Sci 2014;84(4):487-491.
11. Murphy K, Balow K, Lyon SR, Jones SS. Response to selection, combining ability and heritability of coleoptiles length in winter wheat. Euphytica 2008;164(3):709-718.
12. Sharma S, Chaudhary HK. Combining ability and gene action studies for yield contributing traits in crosses involving winter and spring wheat genotypes. Acta Agro. Hungarica 2009;57(4):417-423.
13. Singh MK, Sharma PK, Tyagi BS, Singh G. Combining ability analysis for yield and protein content in bread wheat (*Triticum aestivum* L.). Indian J. of Agri. Sci 2014;84(3):328-336.
14. Yadav J, Sharma SN, Jakhar ML, Shweta. Combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L.) over environments. International J. of Pla. Sci., (Muzaffarnagar) 2017;12(2):95-101.
15. Zahid, Akram, Ajmal SU, Khan KS, Qureshi R, Zubair M. Combining ability estimates of some yield and quality related traits in spring wheat (*Triticum aestivum* L.). Pak. J. of Bot 2011;43(1):221-231.
16. Gaurav BB, Verma SS, Ali PNM, Meena MR. Character association and genetic divergence for quantitative traits in bread wheat. Annals of Bio 2014;30(1):62-67.