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Combining ability analysis in direct crosses for yield and yield related traits among bread wheat (*Triticum aestivum* L.)

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Abstract
A diallel crosses was practiced among twelve diverse bread wheat (*Triticum aestivum* L.) cultivars. The study of only F_1 of the sixty-six direct crosses and the twelve parents were grown in a field experiment at IARI-ICAR, Sub-Station (Wheat), Indore environment in 2017-18 to estimate combining abilities. Data revealed that the mean square of genotypes, parents and crosses were significant for all studied characters. The analysis of variance for combining ability showed that mean square due to general (GCA) and specific (SCA) combining ability, were generally significant for all studied characters reflecting the importance of both additive and non- additive gene effects in the inheritance of these characters. Combining ability were lower than those of specific combining ability, consequently the GCA/SCA ratios were less than unity indicating the prevailing of non-additive gene effect which have considerable roles in the inheritance of these characters. In general, the genotype AKAW-4924 was a good combiner for early flowering and maturity, 1000 grain weight. AKAW-4925 was good combiner for number of grain per earhead and high grain yield/plot and AKW-1071 for number of effective tillers per plant. Besides K-307 was a good combiner for tall plant. These results seem to be useful for wheat breeding program in making the proper decision when initiating a crossing plan.

Keywords: Bread wheat, combining ability (GCA and SCA), diallel, additive, non-additive

Introduction
Wheat (*Triticum aestivum* L.) occupies a pivotal position among cereal crops. It is a leading grain crop of the temperate climate of the world, just like rice in the tropics. It is the dietary mainstay for millions of the people. It is a chief source of caloric and other valuable nutritive materials notably protein requirements of our people. To increase the yield potential of the wheat varieties information on the genetic mechanisms, like combining ability is of major importance. Sprague and Tatum (1942) [17] defined combining ability and divided it in to general and specific combining ability. Combining ability analysis developed by Griffing (1956) [9] has been extensively used to derive such information in F_1 generation. Its method I, and model I is the best in that it also gives the information for the effects of reciprocals.
The main objectives of this study were to detect the magnitude of both general and specific combining ability (GCA and SCA) for grain yield and some agronomic characters in 66 wheat crosses made among twelve bread wheat genotypes using one-way diallel crosses.

Materials and Methods
The present study was carried out during the two successive seasons 2016-17 and 2017-18 at the IARI-ICAR, Sub-Station (Wheat), Indore. The aim of this work was to study only direct crosses the general (GCA) and specific (SCA) combining ability through diallel mating among twelve different wheat varieties. These genotypes represent a wide range of variability. In 2016-17 season, the twelve parental genotypes were planted and all possible combinations of crosses without reciprocals between each two of the twelve parents were done to produce 66 F_1 hybrids. In 2017-18 season, seeds of the sixty-six F_1 (direct) crosses and the twelve parents were sown in randomized block design (RBD) with three replications. Each plot consisted of one rows for parents and F_1. Each row was 2 m long and 20 cm apart, and the seeds within row were spaced 10 cm apart. All recommended cultural practices were considered.
Data were recorded on 5 individual guarded plants chosen at random from each row. The studied characters were number of days to 50% flowering, number of days to maturity, plant height (cm), number of effective tiller/plant, number of grains/earhead, grain weight/earhead (g), 1000-grain weight (g) and grain yield/plot (kg). Data analysis was done according to Singh and Chaudhari (1977) [18], General and specific combining ability estimates were

obtained by employing Griffing diallel cross analysis, model 1 (fixed model) method 1 (Griffing, 1956) [9].

Results and Discussion

Analysis of variance

The analysis of variance for number of days to 50% flowering, number of days to maturity, plant height (cm), number of effective tiller/plant, number of grains/earhead, grain weight/earhead (g), 1000-grain weight (g) and grain yield/plot (kg) are presented in table 1. The results reflected that the mean sum of squares due to GCA, SCA due to direct crosses were highly significant for all studies traits.

The significant variances due to both general and specific combining abilities reflect the importance of additive and non-additive types of gene actions. However, general combining ability effects which were low magnitude suggested the predominant role of non-additive gene action. This result supported by the less than unity of GCA and SCA values, indicating that non-additively play a considerable role in the inheritance of these characters. Therefore, selection in the early generation could be successfully practiced to improve these characters.

These results were agreed with those reported by Bhutta *et al.* (1997) [4], Muhammad Akbar *et al* (2009) [13], Cifci and Yagdi (2010) [6], Gami *et al.* (2010) [8], Burungale *et al.* (2011) [5], Jain and Sastry (2012) [11].

Genotypic performance

The means performance of the twelve wheat parental genotypes was presented in table 2. It is obvious that K-307 genotype as the shortest cultivar. It was also the earliest maturity and had No. of effective tillers/ plant and 1000 grain weight. However, AKAW-4925 and HPBW-01 had the tallest plant and earliest flowering as well as maturity, respectively. AKAW-4924 ranked first as highest productive cultivar. On the other hand, AKAW-5014 and AKAW-4627 were intermediate for all studied characters.

The means performance of the tested sixty-six direct crosses presented in table 2 indicates that for plant height, the tallest four crosses were AKAW-4924 x HPBW-01, K-0307 x GW-322, WB-2 x GW-322 and AKAW-5014 x WB-2. The four crosses AKAW-4924 x AKAW-4210-6, AKAW-5017 x AKAW-4627 and AKAW-5017 x AKAW-4925 were the earliest in maturity. In addition, the three crosses AKAW-4210-6 x WB-2, AKAW-4210-6 x AKW-1071 and AKAW-5017 x GW-322 possessed the highest number of effective tillers/plant, while the three crosses AKAW-4925 x AKAW-4210-6, MACS-6222 x WB-2 and AKAW-5014 x AKAW-4627 gave the highest number of grain/earhead.

For heavy kernel weight, the best four crosses AKAW-4627 x MACS-6222, AKAW-5014 x WB-2, AKAW-4925 x WB-2 and K-0307 x HPBW-01. On the other side, the four crosses AKAW-4210-6 x WB-2, AKAW-4627 x AKW-1071, AKAW-4924 x AKAW-4627 and AKAW-4627 x K-0307 had in the highest grain yield/plant. These results were obtained by Singh *et al.* (2007) [19], Barot *et al.* (2014) [2], Baloch *et al.* (2013) [3], Kalhoro *et al.* (2015) [12], Ismail (2015) [10].

General combining ability (GCA)

Estimates of general combining ability effects for each parent are presented in table 3. High positive values would be of great interest in all studied characters except plant height, days to 50% flowering and days to maturity which if had negative values become more useful from the breeder's point of view. Results indicated that the cultivar AKAW-4925 proved to be a good combiner for grain yield/plant followed by AKAW-4924 and AKW-1071, but the other three parents exhibited negative SCA for this character. AKAW-4627 showed also positive GCA for flowering, maturity and 1000 grain weight. The results indicated that cultivar K-307 showed significant negative combining ability for all studied characters except number of days of flowering and maturity. Moreover, the cultivar MACS-6222 showed negative general combining ability effects for plant height, number of grains/earhead, grain weight/earhead and 1000 grain weight. The cultivar HPBW-01 showed significant negative general combining ability effects for maturity, 1000 grain weight. The crosses involving these good generals combining ability genotypes should produce promising sergeants with higher mean performance of those character. Consequently, the results of the average performance of the respective characters are in agreement with those reported by Ankita Singh *et al* (2012) [1], Raj Preeti and Kandalkar (2013) [15], Dholariya *et al* (2014) [7], Patel (2015) [14], Raiyani *et al* (2015) [16], Uzair *et al* (2016) [20].

Specific combining ability effects

Specific combining ability effects for each cross are presented in table 4. Specific combining ability effects can be defined as the magnitude of deviation exhibited by the parental line in the cross from its expected performance on the basis of its general combining ability (GCA) effects. A significant deviation from zero in cross would indicate especially high or low specific combining ability (SCA) according to the sign wither positive or negative. The crosses AKAW-1071 x MACS-6222, AKAW-5014 x MACS-6222 and AKAW-4924 x AKAW-4210-6 showed significant specific combining ability effects for early maturity. Also, AKAW-5017 x AKAW-4924, AKAW-5017 x GW-322, AKAW-5014 x AKW-1071, AKAW-4925 x MACS-6222, AKAW-4925 x HPBW-01 and WB-2 x GW-322 crosses showed significant positive specific combining ability effects for number of effective tillers/plant, number of grains/earhead, grain weight/earhead, and grain yield/plot respectively. The crosses AKAW-5017 x AKAW-5014, AKAW-5014 x AKW-1071, AKAW-5017 x GW-322, AKAW-5014 x AKW-1071, AKAW-4925 x MACS-6222, AKAW-4925 x HPBW-01 and WB-2 x GW-322 are considered promising for grain yield improvement as they showed high specific combining ability effects. These crosses could account for the highest average performance of the respective characters. In such hybrids, desirable transgressive segregates would be expected in the subsequent genotypes. Similar results were obtained by Raj Preeti and Kandalkar (2013) [15], Dholariya *et al* (2014) [7], Patel (2015) [14], Raiyani *et al* (2015) [16], Uzair *et al* (2016) [20].

Table 1: Mean squares from analysis of variance for combining ability analysis of all studied characters in bread wheat crosses

Sources of variation	df	Days to 50% flowering	Number of days to maturity	Plant height (cm)	No. of effective tillers/plant	Number of grains/earhead	Grain weight/ earhead (g)	1000 Grain weight (g)	Grain yield (Kg/plot)
GCA	11	13.273**	8.345**	58.679**	1.492**	92.284**	0.255**	54.288**	0.009**
SCA crosses	66	13.424**	7.922**	35.183**	2.453**	44.907**	0.152**	23.614**	0.005**
Error	286	0.394	0.479	3.755	0.155	0.869	0.007	1.120	0.000
GCA Vs. SCA		0.041	0.044	0.073	0.024	0.086	0.071	0.098	0.077

Significance Levels* = <.05, **= <.01

Table 2: Mean performance of the twelve parents and their F_1 (direct crosses) for the studied characters

S. No.	Genotypes	Days to 50% flowering	Number of days to maturity	Plant height (cm)	No. of effective tillers/ plant	Number of grains / earhead	Grain weight / earhead (g)	1000 Grain weight (g)	Grain yield (Kg/plot)
Parents									
1	AKAW-5017	75	127	62.78	4.33	34.27	1.31	41.40	0.16
2	AKAW-5014	75	119	80.67	5.33	60.53	2.83	50.46	0.25
3	AKAW-4924	74	125	76.67	5.57	35.33	1.13	51.51	0.32
4	AKAW-4925	73	126	89.33	6.33	47.07	2.89	53.79	0.30
5	AKAW-4627	75	126	76.33	7.57	59.40	2.64	45.83	0.24
6	AKAW-4210-6	76	126	74.89	4.20	29.13	1.26	46.80	0.12
7	AKW-1071	77	120	74.33	8.67	48.40	1.68	37.27	0.10
8	K-307	73	124	72.11	7.67	44.83	1.71	36.05	0.10
9	MACS-6222	74	125	72.78	6.23	44.00	1.68	28.68	0.07
10	HPBW-01	78	122	80.78	7.33	49.40	1.73	29.12	0.09
11	WB-2	77	125	75.11	9.10	61.60	1.95	34.18	0.13
12	GW-322	78	120	74.56	7.57	55.13	2.11	33.74	0.12
Crosses									
13	AKAW-5017 x AKAW-5014	68	127	77.94	9.23	52.27	2.41	48.12	0.23
14	AKAW-5017 x AKAW-4924	77	128	75.83	8.77	39.47	1.49	38.58	0.22
15	AKAW-5017 x AKAW-4925	80	120	75.33	8.33	40.20	1.42	35.65	0.22
16	AKAW-5017 x AKAW-4627	79	119	80.45	9.00	39.53	1.74	44.22	0.19
17	AKAW-5017 x AKAW-4210-6	78	121	80.44	9.13	29.33	1.51	37.18	0.12
18	AKAW-5017 x AKW-1071	76	123	79.89	6.87	42.07	1.53	38.51	0.12
19	AKAW-5017 x K-0307	77	122	83.89	7.77	40.07	1.60	39.90	0.17
20	AKAW-5017 x MACS-6222	74	124	81.44	9.00	35.93	1.31	36.53	0.12
21	AKAW-5017 x HPBW-01	75	123	82.44	8.20	35.80	1.38	37.09	0.11
22	AKAW-5017 x WB-2	76	126	81.28	8.77	40.47	1.64	41.63	0.25
23	AKAW-5017 x GW-322	78	121	80.78	10.90	49.40	2.01	43.64	0.29
24	AKAW-5014 x AKAW-4924	67	121	81.78	6.87	46.40	2.17	45.50	0.27
25	AKAW-5014 x AKAW-4925	77	131	83.44	8.87	50.47	2.05	37.34	0.16
26	AKAW-5014 x AKAW-4627	73	122	81.56	7.77	59.00	2.47	42.53	0.23
27	AKAW-5014 x AKAW-4210-6	68	126	84.00	6.77	44.93	1.65	36.80	0.15
28	AKAW-5014 x AKW-1071	75	132	83.55	8.67	42.73	1.48	39.63	0.16
29	AKAW-5014 x K-0307	74	120	86.89	10.33	54.87	2.56	43.78	0.27
30	AKAW-5014 x MACS-6222	75	131	85.22	8.67	42.20	1.54	36.26	0.17
31	AKAW-5014 x HPBW-01	76	119	83.44	7.87	35.73	1.56	40.26	0.14
32	AKAW-5014 x WB-2	74	122	89.55	7.87	39.80	1.96	49.40	0.23
33	AKAW-5014 x GW-322	75	128	71.11	8.00	49.40	2.04	41.18	0.22
34	AKAW-4924 x AKAW-4925	75	122	71.78	7.67	51.47	1.79	41.32	0.15
35	AKAW-4924 x AKAW-4627	73	121	86.00	8.13	58.27	2.52	41.41	0.29
36	AKAW-4924 x AKAW-4210-6	74	118	84.00	7.67	47.67	1.70	35.37	0.07
37	AKAW-4924 x AKW-1071	75	120	71.00	7.33	49.87	1.61	38.58	0.16
38	AKAW-4924 x K-0307	76	121	75.00	6.77	52.33	2.29	37.18	0.23
39	AKAW-4924 x MACS-6222	74	122	72.00	7.87	53.53	1.78	32.50	0.16
40	AKAW-4924 x HPBW-01	72	128	92.00	7.20	47.47	1.92	41.62	0.21
41	AKAW-4924 x WB-2	69	124	86.17	5.90	38.27	1.78	40.29	0.15
42	AKAW-4924 x GW-322	66	125	79.78	9.47	46.67	2.06	44.19	0.25
43	AKAW-4925 x AKAW-4627	71	120	75.78	8.67	57.87	2.29	40.20	0.23
44	AKAW-4925 x AKAW-4210-6	72	121	75.45	8.57	61.27	1.99	36.89	0.26
45	AKAW-4925 x AKW-1071	79	128	70.34	7.00	50.27	2.21	45.73	0.25
46	AKAW-4925 x K-0307	69	122	85.44	6.10	45.73	1.87	43.38	0.17
47	AKAW-4925 x MACS-6222	74	121	82.11	7.20	51.40	1.95	39.18	0.09
48	AKAW-4925 x HPBW-01	72	125	75.78	7.33	50.20	1.87	35.96	0.09
49	AKAW-4925 x WB-2	78	127	73.22	6.00	50.27	2.32	48.62	0.18
50	AKAW-4925 x GW-322	78	126	72.11	7.23	56.27	2.56	47.29	0.26
51	AKAW-4627 x AKAW-4210-6	83	127	74.45	8.77	52.53	2.38	47.20	0.27
52	AKAW-4627 x AKW-1071	80	127	71.11	8.13	53.67	2.44	48.49	0.30
53	AKAW-4627 x K-0307	84	122	63.78	9.10	51.40	2.39	48.21	0.28
54	AKAW-4627 x MACS-6222	77	121	68.89	8.67	53.33	2.91	50.03	0.30
55	AKAW-4627 x HPBW-01	73	123	86.33	8.67	46.73	1.29	39.68	0.12
56	AKAW-4627 x WB-2	76	123	84.89	8.43	43.47	1.43	39.78	0.07
57	AKAW-4627 x GW-322	79	127	83.44	7.10	34.67	1.29	37.24	0.11
58	AKAW-4210-6 x AKW-1071	77	125	76.06	11.10	35.93	1.21	35.78	0.15
59	AKAW-4210-6 x K-0307	66	122	81.11	6.00	43.27	1.61	42.42	0.05
60	AKAW-4210-6 x MACS-6222	73	127	82.55	8.33	47.67	1.70	45.91	0.09
61	AKAW-4210-6 x HPBW-01	74	121	86.22	8.00	41.67	1.65	38.04	0.08
62	AKAW-4210-6 x WB-2	67	120	75.50	11.33	50.47	2.18	46.97	0.31
63	AKAW-4210-6 x GW-322	83	126	72.66	7.10	42.00	1.83	45.41	0.19

64	AKW-1071 x K-0307	82	127	71.33	6.77	48.53	2.34	40.36	0.20
65	AKW-1071 x MACS-6222	77	127	70.67	10.23	38.40	1.43	40.67	0.18
66	AKW-1071 x HPBW-01	79	126	71.22	6.87	50.40	1.92	41.23	0.19
67	AKW-1071 x WB-2	77	126	76.44	5.67	49.07	1.87	42.05	0.12
68	AKW-1071 x GW-322	73	129	85.67	9.23	43.33	1.77	43.93	0.20
69	K-0307 x MACS-6222	73	121	79.89	8.47	47.93	1.68	36.94	0.17
70	K-0307 x HPBW-01	73	120	80.33	6.13	50.20	1.77	47.06	0.14
71	K-0307 x WB-2	76	123	87.78	9.00	48.73	1.81	37.31	0.12
72	K-0307 x GW-322	73	128	91.44	6.90	42.07	1.71	40.80	0.08
73	MACS-6222 x HPBW-01	81	125	74.50	6.77	48.13	2.03	44.93	0.19
74	MACS-6222 x WB-2	80	131	67.33	7.23	59.27	2.75	42.74	0.26
75	MACS-6222 x GW-322	83	127	75.72	7.33	51.60	1.75	40.53	0.20
76	HPBW-01 x WB-2	76	125	84.00	7.67	34.40	1.13	38.72	0.04
77	HPBW-01 x GW-322	74	124	82.44	7.00	49.47	1.90	36.25	0.12
78	WB-2 x GW-322	77	125	87.55	8.23	44.20	1.75	43.57	0.11
	SE(m)±	0.63	0.69	1.93	0.39	0.92	0.08	1.05	0.05
	CD (5%)	1.75	1.92	5.37	1.09	2.58	0.24	2.93	0.03

Table 3: Estimates of general combining ability effects for the studied characters

S. No.	Parents	Days to 50% flowering	Number of days to maturity	Plant height (cm)	No. of effective tillers/plant	Number of grains/earhead	Grain weight/ earhead (g)	1000 Grain weight (g)	Grain yield (Kg/plot)
1	AKAW-5017	0.856**	-0.690**	0.971	0.054	-2.877**	-0.094**	0.240	0.010**
2	AKAW-5014	0.495**	0.213	2.510**	-0.006	0.598*	0.085**	0.970**	0.010**
3	AKAW-4924	-1.102**	-0.759**	0.891	-0.320**	0.437	-0.011	2.329**	0.021**
4	AKAW-4925	1.370**	0.366*	-0.193	0.267**	3.915**	0.282**	2.246**	0.036**
5	AKAW-4627	0.440**	0.921**	0.437	-0.080	-0.943**	0.024	1.046**	-0.003
6	AKAW-4210-6	-0.963**	0.644**	1.520**	-0.445**	-3.143**	-0.118**	-0.341	-0.030**
7	AKW-1071	-0.241	-0.870**	1.222*	0.510**	0.229	-0.028	-0.228	0.016**
8	K-307	0.343*	0.477**	-2.508**	-0.130	-0.549*	-0.029	-0.111	-0.009**
9	MACS-6222	0.079	-0.148	-1.485**	0.092	-0.796**	-0.052*	-1.759**	-0.007**
10	HPBW-01	-0.685**	-0.301	0.025	0.040	0.473*	-0.034	-1.096**	-0.019**
11	WB-2	-0.116	0.407*	-1.153*	0.117	2.476**	-0.029	-2.747**	-0.010**
12	GW-322	-0.477**	-0.259	-2.236**	-0.098	0.179	0.003	-0.550*	-0.016**
	SE (gi)+	0.122	0.135	0.378	0.076	0.182	0.016	0.207	0.002
	C.D.5%	0.398	0.439	1.231	0.249	0.592	0.054	0.672	0.006
	C.D.1%	0.562	0.620	1.734	0.352	0.835	0.077	0.949	0.009

Significance Levels* = <.05, **= <.01

Table 4: Estimates of specific combining ability effects for 66 direct crosses (F_1)

S. No.	Genotypes	Days to 50% flowering	Number of days to maturity	Plant height (cm)	No. of effective tillers/ plant	Number of grains/ earhead	Grain weight/ earhead (g)	1000 Grain weight (g)	Grain yield (Kg/plot)
1	AKAW-5017 x AKAW-5014	-7.815**	0.954	-2.657	0.213	4.216**	0.437**	5.460**	0.069**
2	AKAW-5017 x AKAW-4924	1.282*	1.926**	0.017	0.919**	3.910**	0.246**	-2.709**	0.058**
3	AKAW-5017 x AKAW-4925	-1.690**	-2.532**	0.575	-0.899**	-5.468**	-0.409**	-3.108**	-0.014
4	AKAW-5017 x AKAW-4627	3.574**	-1.255*	1.502	0.279	-6.476**	-0.284**	-0.693	-0.019*
5	AKAW-5017 x AKAW-4210-6	1.644**	1.023	1.529	1.778**	-5.043**	-0.011	0.519	0.018*
6	AKAW-5017 x AKW-1071	-0.412	-0.463	6.050**	-1.254**	0.752	0.086	1.749	-0.029**
7	AKAW-5017 x K-0307	0.171	-1.977**	2.891	0.663	6.296**	0.091	-1.772	0.001
8	AKAW-5017 x MACS-6222	-2.065**	-1.519*	5.422**	0.607	3.777**	-0.040	1.085	-0.051**
9	AKAW-5017 x HPBW-01	0.866	-0.199	1.912	-0.119	1.274	0.012	-2.370*	-0.040**
10	AKAW-5017 x WB-2	2.463**	-0.574	1.396	-0.418	-2.796**	-0.044	0.468	-0.005
11	AKAW-5017 x GW-322	2.324**	-0.241	-0.437	1.800**	6.935**	0.282**	0.590	0.035**
12	AKAW-5014 x AKAW-4924	2.144**	1.356*	1.285	0.800*	0.635	-0.061	-7.082**	-0.079**
13	AKAW-5014 x AKAW-4925	-2.162**	-2.769**	0.481	-0.568	3.291**	-0.025	-2.501**	-0.046**
14	AKAW-5014 x AKAW-4627	-2.398**	0.509	-1.954	1.226**	-6.618**	-0.541**	-5.865**	-0.023**
15	AKAW-5014 x AKAW-4210-6	0.338	1.787**	-1.343	1.225**	0.482	-0.252**	-2.483**	0.020*
16	AKAW-5014 x AKW-1071	1.616**	-1.532*	1.621	0.976**	2.510**	0.477**	6.899**	0.048**
17	AKAW-5014 x K-0307	3.032**	2.120**	-0.094	0.226	-9.046**	-0.446**	-2.331*	-0.020*
18	AKAW-5014 x MACS-6222	3.963**	-2.921**	2.605	-0.396	-2.832**	-0.192*	-2.143*	0.005
19	AKAW-5014 x HPBW-01	0.227	1.398*	4.705**	-0.839*	-2.768**	0.052	4.500**	0.007
20	AKAW-5014 x WB-2	0.657	3.523**	-2.894	-0.571	-2.704**	-0.051	-2.077*	-0.009
21	AKAW-5014 x GW-322	0.019	0.856	1.634	0.147	0.893	-0.195**	-0.762	-0.037**
22	AKAW-4924 x AKAW-4925	-0.731	-0.796	-6.345**	-0.411	-1.715*	-0.399**	-7.441**	-0.094**
23	AKAW-4924 x AKAW-4627	-2.301**	-2.352**	-2.308	-1.017**	0.910	0.073	-3.714**	-0.041**
24	AKAW-4924 x AKAW-4210-6	1.435**	-2.907**	-5.279**	-0.035	7.177**	0.040	-2.349*	-0.003
25	AKAW-4924 x AKW-1071	0.046	1.773**	7.131**	-0.883**	-0.629	-0.023	1.296	-0.044**
26	AKAW-4924 x K-0307	-2.037**	-1.407*	7.110**	0.267	-2.684**	-0.035	1.381	-0.062**

27	AKAW-4924 x MACS-6222	-1.273*	3.551**	-0.553	2.494**	-4.737**	-0.070	1.097	0.055**
28	AKAW-4924 x HPBW-01	-0.676	-2.130**	-1.949	-0.232	2.360**	0.175*	3.428**	-0.012
29	AKAW-4924 x WB-2	-0.245	-2.671**	8.395**	-0.431	5.524**	0.381**	4.365**	0.035**
30	AKAW-4924 x GW-322	0.116	1.329*	-3.355*	0.121	2.188**	0.386**	5.016**	0.075**
31	AKAW-4925 x AKAW-4627	-0.273	1.856**	-1.390	-0.818*	-1.401	-0.165*	3.837**	-0.061**
32	AKAW-4925 x AKAW-4210-6	2.630**	-0.366	-0.418	0.497	4.332**	0.157*	0.258	0.021*
33	AKAW-4925 x AKW-1071	2.741**	2.648**	-1.285	0.865*	2.393**	0.115	0.584	0.023**
34	AKAW-4925 x K-0307	1.491**	0.801	-0.336	0.632	6.838**	0.238**	1.146	0.069**
35	AKAW-4925 x MACS-6222	3.088**	0.759	-3.802*	1.226**	1.718*	0.190*	2.293*	0.046**
36	AKAW-4925 x HPBW-01	-0.315	-0.421	-4.090*	0.900**	5.482**	0.487**	-0.509	0.081**
37	AKAW-4925 x WB-2	-1.884**	0.370	3.368*	0.318	-5.387**	-0.396**	-0.144	-0.030**
38	AKAW-4925 x GW-322	0.810	-1.296*	2.559	0.253	-1.923*	-0.251**	-3.579**	-0.059**
39	AKAW-4627 x AKAW-4210-6	-0.273	-0.921	7.840**	0.175	-1.443	-0.091	-1.420	-0.047**
40	AKAW-4627 x AKW-1071	-2.829**	0.593	-4.555**	2.010**	-2.515**	-0.057	1.193	0.068**
41	AKAW-4627 x K-0307	3.921**	1.745**	4.701**	-0.540	2.429**	0.176*	2.732**	0.027**
42	AKAW-4627 x MACS-6222	3.852**	-0.630	4.013*	-1.362**	3.177**	0.320**	2.418**	0.025**
43	AKAW-4627 x HPBW-01	1.449**	2.190**	-2.885	1.194**	-5.593**	-0.182*	-1.063	0.010
44	AKAW-4627 x WB-2	-2.120**	-0.185	-3.236	-0.238	5.938**	0.171*	0.207	0.018*
45	AKAW-4627 x GW-322	-3.093**	-1.852**	1.846	-0.836*	-2.298**	-0.143	-1.231	-0.040**
46	AKAW-4210-6 x AKW-1071	-0.593	-0.130	-3.887*	-1.475**	2.185**	0.146	-0.518	-0.026**
47	AKAW-4210-6 x K-0307	-1.509**	3.356**	-3.659*	0.558	6.829**	0.490**	0.777	0.045**
48	AKAW-4210-6 x MACS-6222	1.088*	0.148	-0.821	0.386	-1.357	-0.147	-0.375	0.014
49	AKAW-4210-6 x HPBW-01	-2.815**	-0.532	3.336	0.210	-5.093**	-0.329**	-0.606	-0.048**
50	AKAW-4210-6 x WB-2	-3.884**	-1.574**	2.541	-0.472	2.204**	0.229**	1.606	-0.003
51	AKAW-4210-6 x GW-322	-1.690**	-1.074	7.347**	-0.138	1.702*	0.135	-2.753**	-0.006
52	AKW-1071 x K-0307	-4.065**	-2.296**	0.056	-0.957**	-1.943*	0.093	-0.081	-0.064**
53	AKW-1071 x MACS-6222	-7.634**	-3.005**	-2.217	1.488**	-1.829*	-0.308**	-2.403**	0.038**
54	AKW-1071 x HPBW-01	0.630	1.648**	8.330**	-0.806*	0.635	-0.185*	-0.714	0.085**
55	AKW-1071 x WB-2	4.394**	-1.394*	-2.827	-0.054	-2.134**	-0.264**	-3.434**	-0.029**
56	AKW-1071 x GW-322	2.588**	4.273**	-1.272	0.231	0.029	0.046	-2.159*	0.022*
57	K-0307 x MACS-6222	-0.718	0.315	-0.237	0.088	5.116**	0.289**	2.115*	0.059**
58	K-0307 x HPBW-01	-0.287	-2.199**	-2.107	1.011**	-1.687*	-0.127	0.034	0.021*
59	K-0307 x WB-2	1.144*	-1.741**	-0.596	0.229	-3.223**	-0.389**	-3.552**	-0.015
60	K-0307 x GW-322	0.171	2.093**	-5.819**	-2.303**	-7.459**	-0.288**	3.418**	-0.017
61	MACS-6222 x HPBW-01	0.310	2.093**	-1.408	0.072	1.727*	0.042	5.139**	-0.023**
62	MACS-6222 x WB-2	0.241	2.218**	0.490	-1.610**	-0.643	0.169*	-1.188	-0.031**
63	MACS-6222 x GW-322	-1.065	-2.449**	-0.204	-1.242**	-2.312**	-0.169*	-0.101	-0.057**
64	HPBW-01 x WB-2	-1.495**	-0.296	-5.130**	-0.336	0.854	0.106	-0.835	-0.031**
65	HPBW-01 x GW-322	-2.968**	-0.296	-2.407	-0.518	1.752*	0.018	1.818	-0.018*
66	WB-2 x GW-322	-2.204**	1.995**	0.112	2.517**	-6.884**	-0.055	5.047**	0.112**
	SE (Sij)	0.409	0.450	1.261	0.256	0.607	0.056	0.689	0.007
	SE (Sij-Skl)	0.573	0.632	1.769	0.359	0.851	0.079	0.966	0.009

Significance Levels* = <.05, **= <.01

Conclusion

In conclusion, genotype AKAW-4924 was a good combiner for early flowering and maturity, 1000 grain weight. AKAW-4925 was good combiner for number of grain per earhead and high grain yield/plot. AKW-1071 for number of effective tillers per plant. Besides K-307 was a good combiner for plant height. This result may useful to wheat breeders in making the proper decision for future crossing plants.

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