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Analyzing combining ability and gene action for grain yield and its associated traits in bread wheat. (*Triticum aestivum* L.)

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Abstract
The present investigation was undertaken in order to estimate the combining ability and gene action for grain yield and its components in bread wheat (*Triticum aestivum* L.) for 13 characters. The crosses were attempted by using line × tester mating design among 8 lines and 4 testers during rabi 2019. The resultant 32 hybrids together with 12 parents and 1 standard check (GW 451) were tested using randomized block design with three replications at Wheat Research Station, Junagadh Agricultural University, Junagadh during rabi 2020-21. Combining ability analysis revealed that both GCA and SCA variances were more or less important for inheritance of most of the characters under study. However, the magnitude of SCA variance was higher than GCA variance for all the characters (except number of spikelets per main spike) indicated the predominance of non-additive gene action in the inheritance of these characters. The line J 16-08 and tester GW 499 were good general combiners for grain yield per plant and some of its component traits. Seven crosses exhibited significant and positive SCA effects for grain yield per plant. Among them, the highest SCA effects was manifested by the cross GW 513 × GW 11 followed by HD 3086 × HI 1544 and AKAW 4901 × GW 366. The cross HD 3086 × HI 1544 was also found good specific combiner for harvest index. Likewise, the cross AKAW 4901 × GW 366 exhibited significant SCA effect for flag leaf area, 100-grain weight and harvest index. So these could be further exploited in practical plant breeding programme.

Keywords: Bread wheat, line × tester analysis, combining ability, gene action, grain yield

Introduction
Wheat, one of the world's oldest crops, has been cultivated for about 10,000 years since the Neolithic Revolution. Its origin can be traced back to wild einkorn and emmer wheat. By 5000 B.C., bread wheat was grown in the Nile valley and later spread to regions like the Indus, Euphrates valleys, China, and England. Wheat has been vital in West Asia and Europe, serving as a primary source of bread, while rice dominated in East Asia. Its adaptability, versatility, and genetic traits, including polyploidy, have made it economically and nutritionally significant, especially with the emergence of hexaploid wheat (Dubcovsky & Dvorak 2007) [8].
Wheat belongs to the genus *Triticum* of Poaceae family and believed to be originated from South West Asia (Lupton, 1987) [12]. In fact, there are three natural group of wheat from polyploid series of *Triticum* species *viz. Triticum aestivum* a hexaploid wheat (bread wheat) which is having chromosome number 2n = 42, *Triticum durum*, a tetraploid wheat (macaroni wheat) with chromosome number 2n = 28 and *Triticum dicoccum*, also a tetraploid wheat (emmer wheat) with chromosome number 2n = 28 are presently grown as commercial crop in India.
A significant boost in production is essential not only to meet the increasing domestic food demand but also to generate foreign exchange through exports. To meet the projected wheat requirement of 140 million metric tonnes by 2050 and ensure food security for the growing population, annual wheat production must increase by more than 1 percent. This can be accomplished through either expanding cultivation areas (horizontal approach) or enhancing varietal improvement (vertical approach), a powerful strategy to significantly increase production and productivity across diverse agro-climatic conditions.
The combining ability study is a powerful tool to discriminate good as well as poor combiners for choosing appropriate parental material in plant breeding program. Moreover, information regarding general and specific combing ability enables the plant breeder to evaluate parental material and to decide a suitable breeding procedure for character improvement.

The knowledge of nature and magnitude of fixable and non-fixable types of gene effects governing the yield and its components is essential in order to formulate an efficient and a sound breeding programme to achieve the maximum genetic improvement in bread wheat.

Materials and Methods

Eight lines (females) namely, J 16 - 08, J 18 - 16, J 17 - 08, GW 513, AKAW 4901, HS 626, WH 1216, HD 3086 and four testers (males) i.e. GW 366, GW 11, HI 1544, GW 499 of bread wheat (*Triticum aestivum* L.) were selected on the basis of their phenotypic variability. The crossing programme was carried out during *rabi* 2019-20 using line × tester mating design. The experimental material consisting of 45 entries, including 12 parents, 32 crosses and 1 standard check were tested in randomized block design with three replications during *rabi* 2020-21. A single row plot of 2.5 meters was allotted randomly to each entry. The row-to-row and plant-to-plant distance was kept 22.5 cm and 10 cm, respectively. All the recommended cultural practices and plant protection measures were followed to grow healthy crop. Five competitive plants per genotype in each replication were randomly selected for the purpose of recording observations on for 13 characters, *viz.*, days to heading, days to maturity, plant height, flag leaf area, number of effective tillers per plant, length of main spike, number of spikelets per main spike, grain filling period, number of grains per main spike, 100-grain weight, grain yield per plant, biological yield per plant and harvest index. Analysis of variance for combining ability was carried-out according to the method suggested by Kempthorne (1957) [9].

Results and Discussion

The analysis of variance for combining ability for all the thirteen traits is presented in Table 1. [It was carried out according to the line × tester design proposed by Kempthorne (1957) [9] which is analogous to North Carolina Design-II of Comstock and Robinson (1948, 1952).] Mean squares due to lines, testers and their interactions (line × tester) were first tested against the error mean squares. If line × tester interaction mean squares were found significant, more stringent test of significance was applied and the mean squares of lines and testers were further tested against lines × testers means squares.

The gca variance was observed greater than the sca variance for the trait number of spikelets per main spike, which indicated preponderance of additive gene action in the inheritance of these trait. Therefore, selection for these traits in early generations would be effective for developing the superior varieties in wheat breeding programme. This was further supported by σ^2gca/ σ^2sca ratio greater than unity. Preponderance of additive variance in expression of these traits in wheat have also been reported by Dhadhal *et al.* (2008) [6], Barot *et al.* (2014) [4], Kumar and Prasad (2017) [10], Dhoot *et al*. (2020) [7].

The magnitude of sca variance were higher than gca variance for the characters, *viz.*, days to heading, days to maturity, plant height, flag leaf area, number of effective tillers per plant, length of main spike, 100-grain weight, grain yield per plant, biological yield per plant and harvest index, which indicated preponderance of non-additive gene action in the inheritance of these traits. The magnitude of gca and sca variances were just similar for grain filling period and number of grains per main spike. Similar findings were also reported by Pansuriya *et al.* (2014) [14], Dedaniya *et al*. (2019) [5] and Bajaniya *et al.* (2019) [3] for days to heading, days to maturity, plant height, grain yield per plant, biological yield per plant and harvest index; Zeeshan *et al.* (2013) [15] and Kumar *et al*. (2015) [11] for flag leaf area and number of effective tillers per plant; Murugan and Kannan (2017) [13] for length of main spike and 100-grain weight; Bajaniya *et al.* (2019) [3] for grain filling period; Kumar and Prasad (2017) [10] for number of grains per main spike.

The overview of general combining ability effects of the parents reveals that none of the parents was found to be good general combiner for all the characters. An overall appraisal of general combining ability effects of parents revealed that female parents J 16-08, J 17-08, GW 513 and HD 3086, male parent GW 499 were found to be good general combiners for days to heading. Regarding days to maturity, lines HD 3086 and J 17-08, tester GW 499 were recorded as good general combiners. The good general combining ability effect was expressed by the female parents AKAW 4901 and HD 3086 for plant height. Concerning flag leaf area, line WH 1216 and tester GW 499 were registered as good general combiners. The estimate of general combining ability effect revealed that female parents J 16-08, GW 513 and J 18-16 and male parent GW 366 exhibited good general combining ability effects for number of effective tillers per plant. Female parents J 16-08, HS 626 and WH 1216 showed significant positive general combining ability effects for length of main spike. For number of spikelets per main spike line J 16-08 registered as good general combiners. Regarding grain filling period, female parents J 16-08, J 17-08, GW 513 and male parent GW 499 showed significant negative general combining ability effects. Female parent GW 513 and male parent GW 366 were recorded as good general combiners for number of grains per main spike. For 100-grain weight, female parent AKAW 4901 and male parent GW 499 were emerged as good general combiners. For grain yield per plant, female parent J 16-08 and male parent GW 366 exhibited significant positive general combining ability effects. For biological yield per plant, female parents J 16-08 and HS 626 while male parent GW 11 manifested significant positive general combining ability effects. Line J 16-08 whereas testers GW 366 and GW 499 were noted as good general combiners for harvest index (Table 2).

The results of specific combining ability effects of different crosses revealed that none of the crosses showed consistently significant and desirable specific combining ability effects for all the characters simultaneously (Table 3). Seven crosses showed significant positive specific combining ability effects for grain yield per plant. The highest *sca* effect for grain yield per plant was showed by the cross GW 513 × GW 11 (average × poor) followed by HD 3086 × HI 1544 (average × poor) and AKAW 4901 × GW 366 (poor × good). Considering the desired *sca* effects, the best cross combination were J 17-08 × GW 11 for days to heading, J 16-08 × GW 499 for days to maturity, J 17-08 × GW 499 for plant height, WH 1216 × GW 11 for flag leaf area, J 18-16 × HI 1544 for number of effective tillers per plant, J 17-08 × GW 11 for length of main spike, No significant cross for number of spikelets per main spike, J 18-16 × HI 1544 for grain filling period, WH 1216 × GW 11 for number of grains per main spike, HS 626 × HI 1544 for 100-grain weight, GW 513 × GW 11 for grain yield per plant, GW 513 × GW 11 for biological yield per plant and WH 1216 × GW 11 for harvest index.

Table 1: Analysis of variance for combining ability and variance components for different characters in bread wheat

Source	df	Days to heading	Days to maturity	Plant height	Flag leaf area	Number of effective tillers per plant	Length of main spike	Number of spikelets per main spike
Replications	2	13.791*	3.791	6.605	5.866*	0.566	0.588	1.131
Lines	7	63.517**++	32.700**	105.200**	3.231	8.571**	4.528**++	5.156**+
Testers	3	40.569**	8.260	24.379	45.299**	12.995**	0.375	1.526
Lines x Testers	21	16.855**	15.935**	56.662**	21.837**	10.317**	0.938**	1.434
Error	62	4.307	5.017	16.024	1.828	0.746	0.300	1.115
Variance Components								
σ^2 l		4.934**	2.307	7.431	0.116	0.652	0.352**	0.336
σ^2 t		1.510	0.135	0.348	1.811	0.510	0.003	0.017
σ^2 lt		4.182**	3.639**	13.546**	6.669**	3.190**	0.212**	0.106
σ^2 gca		2.652**	0.859*	2.709	1.246	0.557	0.119**	0.123
σ^2 sca		4.182**	3.639**	13.546**	6.669**	3.190**	0.212**	0.106
σ^2 gca/σ^2 sca		0.634	0.236	0.199	0.186	0.174	0.550	1.160

Table Contd…

*, ** Significant at 5% and 1% against error, respectively

+, ++ Significant at 5% and 1% levels, respectively against line × tester interaction

The estimation of genetic variance contributed by lines (σ^2l) and testers (σ^2t)

Table 1: Continue

Source	df	Grain filling period	Number of grains per main spike	100-grain weight	Grain yield per plant	Biological yield per plant	Harvest index
Replications	2	3.218	2.177	0.255*	5.767**	9.310	80.195*
Lines	7	49.141**++	42.358**	0.276**	26.933**+	163.838**	55.948**
Testers	3	22.677**	159.549**++	1.256**+	16.134**	34.200**	191.190**
Lines x Testers	21	8.740**	25.066**	0.292**	8.516**	177.968**	160.233**
Error	62	2.982	8.526	0.072	1.036	7.687	17.585
Variance Components							
σ^2 l		3.846**	2.819	0.017	2.158*	13.012	3.196
σ^2 t		0.820	6.292**	0.049*	0.629	1.104	7.233
σ^2 lt		1.919**	5.513**	0.073**	2.493**	56.760**	47.549**
σ^2 gca		1.829**	5.134**	0.038**	1.138**	5.074	5.888
σ^2 sca		1.919**	5.513**	0.073**	2.493**	56.760**	47.549**
σ^2 gca/σ^2 sca		0.953	0.931	0.520	0.456	0.089	0.123

*, ** Significant at 5% and 1% against error, respectively

+, ++ Significant at 5% and 1% levels, respectively against line × tester interaction

The estimation of genetic variance contributed by lines (σ^2l) and testers (σ^2t)

Table 2: General combining ability effects for different characters in bread wheat

Sr. No.	Parents	Days to heading	Days to maturity	Plant height	Flag leaf area	Number of effective tillers per plant	Length of main spike	Number of spikelets per main spike
Lines								
1	J 16 - 08	-2.521**	-0.094	2.803*	-0.747	1.287**	0.727**	1.129**
2	J 18 - 16	2.063**	0.656	-0.561	0.179	0.538*	-1.256**	-0.904**
3	J 17 - 08	-2.354**	-1.427*	-1.024	-0.373	0.008	-0.440**	-0.538
4	GW 513	-1.854**	-0.844	-2.080	0.539	0.679**	-0.006	-0.221
5	AKAW 4901	2.229**	1.156	-3.647**	-0.016	-0.770**	0.110	0.146
6	HS 626	3.063**	2.656**	4.403**	-0.072	-1.370**	0.435**	0.596
7	WH 1216	0.896	0.573	2.803*	0.853*	-0.020	0.369*	0.196
8	HD 3086	-1.521*	-2.677**	-2.697*	-0.363	-0.352	0.060	-0.404
	SE(gi)	0.599	0.646	1.155	0.390	0.249	0.158	0.304
	CD at 5%	1.197	1.292	2.310	0.780	0.498	0.316	0.609
Testers								
1	GW 366	0.438	0.323	1.270	0.119	0.964**	0.023	0.187
2	GW 11	0.771*	0.531	-0.218	-1.293**	0.158	-0.181	0.021
3	HI 1544	0.729	-0.052	0.120	-0.694**	-0.703**	0.056	0.154
4	GW 499	-1.938**	-0.802*	-1.172	1.869**	-0.419**	0.102	-0.363
	SE(gi)	0.423	0.457	0.817	0.276	0.176	0.111	0.215
	CD at 5%	0.846	0.914	1.633	0.551	0.352	0.223	0.431

*, ** Significant at 5% and 1% against error, respectively *Table contd…*

Table 2: Contd.

Sr. No.	Parents	Grain filling period	Number of grains per main spike	100-grain weight	Grain yield per plant	Biological yield per plant	Harvest index
			Lines				
1	J 16 - 08	3.448**	0.875	-0.100	3.022**	4.685**	3.017*
2	J 18 - 16	-1.219*	-1.497	-0.024	-2.243**	-7.606**	0.781
3	J 17 - 08	1.115*	-0.266	-0.287**	0.391	-1.211	1.462
4	GW 513	1.615**	3.546**	-0.009	-0.190	-0.713	0.785
5	AKAW 4901	-2.469**	-1.094	0.233**	-1.127**	0.083	-3.592**
6	HS 626	-2.302**	0.689	0.021	0.142	3.490**	-2.497*
7	WH 1216	-0.219	-2.683**	0.083	0.182	0.009	0.740
8	HD 3086	0.031	0.431	0.083	-0.178	1.264	-0.696
	SE(gi)	0.498	0.842	0.077	0.293	0.800	1.210
	CD at 5%	0.996	1.685	0.155	0.587	1.599	2.419
			Testers				
1	GW 366	0.573	3.713**	-0.094	1.155**	-0.386	3.036**
2	GW 11	-0.802*	-2.145**	-0.257**	-0.491**	1.313**	-2.108**
3	HI 1544	-0.844**	-0.380	0.073	-0.665**	0.530	-2.678**
4	GW 499	1.073**	-1.188*	0.277**	0.001	-1.457**	1.751*
	SE(gi)	0.352	0.596	0.055	0.207	0.565	0.856
	CD at 5%	0.704	1.191	0.110	0.415	1.131	1.711

*, ** Significant at 5% and 1% against error, respectively

Table 3: Specific combining ability effects for days to heading, days to maturity, plant height, flag leaf area and number of effective tillers per plant in bread wheat

Sr. No.	Hybrids	Days to heading	Days to maturity	Plant height	Flag leaf area	Number of effective tillers per plant
1	J-16-08 x GW366	-2.688*	-0.906	-0.386	0.028	-0.439
2	J-16-08 x GW11	4.979**	5.552**	0.701	-0.970	1.671**
3	J-16-08 x HI1544	-0.979	-1.531	-0.036	1.738*	-3.062**
4	J-16-08 x GW499	-1.313	-3.115*	-0.278	-0.796	1.830**
5	J-18-16 x GW366	-0.604	0.344	0.178	-1.864*	-1.487**
6	J-18-16 x GW11	-0.271	-1.865	-3.191	-0.236	-0.047
7	J-18-16 x HI1544	1.438	2.719*	1.261	1.412	2.774**
8	J-18-16 x GW499	-0.563	-1.198	1.753	0.688	-1.241*
9	J-17-08 x GW366	0.146	-0.240	6.908**	2.091**	1.719**
10	J-17-08 x GW11	-4.521**	-2.115	3.019	-0.083	0.059
11	J-17-08 x HI1544	4.188**	1.135	-4.142	-0.722	-2.270**
12	J-17-08 x GW499	0.188	1.219	-5.784*	-1.286	0.492
13	GW513 x GW366	0.646	1.510	-0.903	-3.264**	-1.508**
14	GW513 x GW11	-1.021	-1.031	0.651	-2.999**	0.838
15	GW513 x HI1544	-2.313	-1.448	-1.286	3.752**	1.222*
16	GW513 x GW499	2.688*	0.969	1.539	2.512**	-0.552
17	AKAW4901 x GW366	1.563	1.510	-3.803	3.037**	-0.106
18	AKAW4901 x GW11	2.563*	1.969	-2.516	-1.737*	-1.549**
19	AKAW4901 x HI1544	-3.063*	-1.448	0.214	-0.487	1.188*
20	AKAW4901 x GW499	-1.063	-2.031	6.105*	-0.813	0.467
21	HS626 x GW366	1.063	-0.323	1.214	-1.937*	0.137
22	HS626 x GW11	0.063	0.135	7.234**	1.718*	1.997**
23	HS626 x HI1544	-0.229	-2.281	-3.170	-2.041*	-0.938
24	HS626 x GW499	-0.896	2.469	-5.278*	2.259**	-1.196*
25	WH1216 x GW366	-0.438	-2.240	-4.720*	-0.315	-0.766
26	WH1216 x GW11	-0.771	-1.448	-3.432	5.733**	-2.139**
27	WH1216 x HI1544	-0.396	1.469	8.364**	-4.662**	0.675
28	WH1216 x GW499	1.604	2.229	-0.211	-0.756	2.230**
29	HD3086 x GW366	0.313	0.344	1.514	2.225**	2.450**
30	HD3086 x GW11	-1.021	-1.198	-2.466	-1.427	-0.830
31	HD3086 x HI1544	1.354	1.385	-1.203	1.011	0.411
32	HD3086 x GW499	-0.646	-0.531	2.155	-1.809*	-2.031**
	SE±	1.198	1.293	2.311	0.780	0.498
	CD at 5%	2.395	2.585	4.619	1.560	0.996

*, ** Significant at 5% and 1% against error, respectively

Table 4: Specific combining ability effects for length of main spike, number of spikelets per main spike, grain filling period and number of grains per main spike in bread wheat

Sr. No.	Hybrids	Length of main spike	Number of spikelets per main spike	Grain filling period	Number of grains per main spike
1	J-16-08 x GW366	0.060	0.879	2.010*	1.105
2	J-16-08 x GW11	0.298	0.912	-1.281	0.276
3	J-16-08 x HI1544	-0.173	-1.221*	-1.240	0.289
4	J-16-08 x GW499	-0.185	-0.571	0.510	-1.670
5	J-18-16 x GW366	-0.023	0.179	0.344	-3.139
6	J-18-16 x GW11	-0.519	-0.254	-0.948	0.126
7	J-18-16 x HI1544	0.310	0.613	2.094*	-0.366
8	J-18-16 x GW499	0.231	-0.537	-1.490	3.379*
9	J-17-08 x GW366	-0.106	-0.254	0.677	2.067
10	J-17-08 x GW11	1.165**	0.713	2.052*	-1.259
11	J-17-08 x HI1544	-0.406	-0.354	-2.906**	-1.970
12	J-17-08 x GW499	-0.652*	-0.104	0.177	1.161
13	GW513 x GW366	0.227	-0.037	-1.490	0.334
14	GW513 x GW11	-0.502	-0.804	-0.115	-1.464
15	GW513 x HI1544	0.394	0.996	-0.073	-0.802
16	GW513 x GW499	-0.119	-0.154	1.677	1.932
17	AKAW4901 x GW366	0.177	0.129	-0.740	-2.836
18	AKAW4901 x GW11	0.048	-0.304	0.302	1.296
19	AKAW4901 x HI1544	-0.823*	-0.571	1.677	0.641
20	AKAW4901 x GW499	0.598	0.746	-1.240	0.899
21	HS626 x GW366	-0.248	0.079	-0.906	5.249**
22	HS626 x GW11	0.523	0.379	0.802	-3.437*
23	HS626 x HI1544	0.552	0.113	-1.156	1.579
24	HS626 x GW499	-0.827*	-0.571	1.260	-3.390*
25	WH1216 x GW366	0.085	-0.587	1.344	-4.710**
26	WH1216 x GW11	-0.344	-0.154	-0.281	5.445**
27	WH1216 x HI1544	-0.015	0.512	1.760	1.824
28	WH1216 x GW499	0.273	0.229	-2.823**	-2.559
29	HD3086 x GW366	-0.173	-0.388	-1.240	1.929
30	HD3086 x GW11	-0.669*	-0.488	-0.531	-0.983
31	HD3086 x HI1544	0.160	-0.088	-0.156	-1.194
32	HD3086 x GW499	0.681*	0.963	1.927	0.247
	SE±	0.316	0.609	0.997	1.685
	CD at 5%	0.632	1.219	1.993	3.369

*, ** Significant at 5% and 1% against error, respectively

Table 5: Specific combining ability effects for 100-grain weight, grain yield per plant, biological yield per plant and harvest index in bread wheat

Sr. No.	Hybrids	100-grain weight	Grain yield per plant	Biological yield per plant	Harvest index
1	J-16-08 x GW366	0.190	1.473*	4.848**	-1.263
2	J-16-08 x GW11	-0.026	0.602	4.960**	-2.928
3	J-16-08 x HI1544	-0.117	-1.363*	-8.807**	5.362*
4	J-16-08 x GW499	-0.047	-0.712	-1.001	-1.171
5	J-18-16 x GW366	-0.333*	1.356*	5.780**	-1.797
6	J-18-16 x GW11	0.217	-0.375	-3.035	0.534
7	J-18-16 x HI1544	0.347*	-0.691	2.144	-5.306*
8	J-18-16 x GW499	-0.231	-0.290	-4.889**	6.569**
9	J-17-08 x GW366	-0.120	0.728	4.181*	-1.594
10	J-17-08 x GW11	-0.220	-1.256*	-7.660**	3.770
11	J-17-08 x HI1544	0.190	-0.162	-0.044	-0.253
12	J-17-08 x GW499	0.149	0.689	3.523*	-1.922
13	GW513 x GW366	-0.001	-3.804**	-7.550**	-4.630
14	GW513 x GW11	0.259	3.075**	16.291**	-5.763*
15	GW513 x HI1544	0.022	1.336*	0.158	2.214
16	GW513 x GW499	-0.279	-0.607	-8.899**	8.179**
17	AKAW4901 x GW366	0.464**	1.609**	-4.276**	9.787**
18	AKAW4901 x GW11	-0.006	-1.455*	1.412	-5.679*
19	AKAW4901 x HI1544	-0.520**	-0.997	-2.125	-1.309
20	AKAW4901 x GW499	0.063	0.843	4.989**	-2.798
21	HS626 x GW366	-0.131	-0.713	5.216**	-6.435**
22	HS626 x GW11	-0.391*	0.229	-7.582**	6.422*
23	HS626 x HI1544	0.526**	-0.330	6.831**	-5.344*

24	HS626 x GW499	-0.005	0.814	-4.466**	5.357*
25	WH1216 x GW366	0.034	-1.660**	-1.569	-3.762
26	WH1216 x GW11	-0.090	-0.204	-11.104**	11.449**
27	WH1216 x HI1544	0.057	0.293	7.346**	-5.491*
28	WH1216 x GW499	-0.001	1.571**	5.326**	-2.196
29	HD3086 x GW366	-0.103	1.010	-6.631**	9.694**
30	HD3086 x GW11	0.257	-0.614	6.717**	-7.805**
31	HD3086 x HI1544	-0.503**	1.913**	-5.503**	10.128**
32	HD3086 x GW499	0.349*	-2.309**	5.417**	-12.017**
	SE±	0.155	0.587	1.600	2.421
	CD at 5%	0.311	1.174	3.199	4.839

*, ** Significant at 5% and 1% against error, respectively

Conclusion

Based on the current findings, it can be deduced that there was a significant degree of variability observed in the material concerning grain yield and its constituent components. Both additive and non-additive components were important for inheritance of different characters studied. The presence of additive gene action would enhance the chances of making improvement through simple selection. The prevalence of both additive and non-additive gene actions suggested the simultaneous exploitation of these gene actions by adopting selective intermating and selection, which could accumulate more of additive genetic variability. The non-additive gene action can be exploited by the breeding procedures involving either heterosis breeding or biparental mating followed by selection. When epistasis is present, pedigree or biparental mating or diallel selective mating systems may prove to be effective in improvement of grain yield and its associated traits in bread wheat.

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