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Combining ability analysis for its components in bread wheat (*Triticum aestivum* L.) using line x tester

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Abstract
Four strains CB-35, CB-212, CB-214 and CB-219 and one commercial variety Miraj-2008 were used as lines (female parents). Two land races LR-01 and LR-02 were used as male parents (testers) design. Line x Tester used in order to estimate the combining ability and genetic components for its important traits. Miraj-2008 proved to be a good general combiner for all traits under study except grain weight per spike. Estimates of variances due togeneral combining ability (GCA), specific combining ability (SCA) and GCA/SCA ratio indicates that traits showed under control of additive gene action which is good for selection and varietal development. The cross-combination CB-214 x LR-02 exhibit good SCAfor number of tillers per plant and days to 50% headings. Both traits contribute to ultimate grain yield. Cross CB-212 x LR-02 possess highest value of SCA for days to taken for anthesis. CB-219 x LR-1 and CB-214 x LR-02 are good specific combiners for days to maturity and grain weight per spike. It is expected that these cross combinations will yield transgressive segregates.

Keywords: combining ability, bread wheat (*Triticum aestivum* L.)

Introduction
Bread wheat (*Triticum aestivum* L.) is a major food crop of the world. In Pakistan wheat was production *was* 25.49 million tons obtained from 8.734 million hectares, showing the decrease of 2.6% in area with average yield of 2919 kg per hectare (Anon, 2018) [3]. It contributes 9.1 % to the value added in agriculture and 1.7 % to GDP. It supplies 72 % of calories and protein. To feed rapidly increasing population of country is a huge challenge for scientists. This could be achieved by wise exploration and utilization of existing genetic variability present in available germplasm. For any successful breeding program availability of genetic variability for desirable traits is a pre-requisite. Plant breeders must focus on crossing good general combines lines and selection transgressive segregates for yield associated traits from hybrids. According to Kinaci (1996) [6] estimates of GCA effects for yield and associated traits helps in selection of desirable parental genotypes. Information regarding combining ability i.e. general combing ability (GCA), specific combining ability (SCA) and nature of gene interaction controlling traits provides firm foundations for successful breeding program. Line x Tester is one of the important breeding mating designs which provides information regarding GCA, SCA effects and gene interaction which consequently helps in suitable parents so that desirable hybrids can be produced (Kinaci, 1996) [6]. According to some scientists, grain yield and related traits are under control of non-additive gene effects (Kruvadi, 1991) [7]. Some research workers [Ahmadi *et al.*, (2003) [1], Akbar *et al.*, (1997) [2], Larik *et al* (1995) [8], Prakasa (1977) [10]] reported that genetic variances of yield and associated traits are under control of additive genes. In another study Akbar *et al.*, (1997) [2] reported the magnitude of additive variances was higher than non-additive variance for grain yield related traits.

Materials and Methods
The plant materials for study consisted of 7 wheat (*Triticum aestivum* L.) genotypes including four strains (CB-35, CB-212, CB-214 and CB-219), one commercial variety (Mairaj-08) and two land races (LR-1 and LR-2) obtained from germplasm resources, Regional Agricultural Research Institute, Bahawalpur. All the genotypes have a breeder seed and sown in two rows of 5m length each separated by 30cm. Recommended cultural practices (like fertilization, irrigation, weeding) were carried out during the whole experimental duration. At the heading stage, crossing was done by Line × Tester fashion by keeping advance strains and commercial variety as lines (female parents) and land races as testers (male parents). Hand emasculation and pollination method was adopted. Twenty pairs of spikes were crossed to get optimum quantity of F_0 seed for each cross. At maturity, crossed spikes were cut, threshed manually, packed and labeled individually for each family. F_0 seeds of each family (hybrids), along with parents (a total of 17 genotypes i.e. 7 parents and 10 crosses) were sown in field during the next wheat growing season at the same experimental station. The experiment was laid out following randomized complete block design replicated thrice. Each experimental plot comprised of 4 rows with each 3m long. Soil of the experimental area was loam to clay loam. Sowing was done with the help of dibbler keeping plant to plant and row to row distance was kept 15cm and 30cm, respectively. All cultural practices were applied the same as recommended as above. Ten adjacent plants were tagged from the two central rows (5 plants from each row) prior to heading stage from each experimental plot. Data for various morpho-physiological traits including plant height, tillers

per plant, days to heading, days to anthesis, days to maturity and grain weight per spike were measured from tagged plants at appropriate stage. The analysis of variance was carried out following Steel and Torrie (1980) [13]. Data for the traits depicting significant difference were further analyzed for Line×Tester (Singh and Chaudhry, 2000) [12].

Table 1: Name of the genotypes used as Lines/Tester

SR#	Lines/Tester	Names
1	Line-01	CB-35
2	Line-02	CB-212
3	Line-03	CB-214
4	Line-04	CB-219
5	Line-05	Mairaj-08
6	Tester-01	LR-1
7	Tester-02	LR-2

Results and Discussion

Analysis of variance showed that significant genotypic difference exists for all traits under study. Estimates of variances due to GCA (σ^2GCA**)**, SCA (σ^2SCA) andσ^2g / σ^2showed that σ^2GCA was greater than σ^2SCA for all traits except days to 50% heading, days to anthesis and grain weight per spike. This indicates predominantly additive gene effects for these traits. Among female parents Miraj-2008 proved to be best general combiner for all traits except grain weight per spike followed by CN-35 which proved to be poor general combiner for traits under study. Two testers used in this study were poor general combiner for all traits. Table-3 shows that cross CB-219 x LR-02 showed good specific combining ability (SCA) for plant height. The cross-combination CB-214 x LR-02 exhibit good specific combining ability (SCA) for number of tillers per plant and days to 50% headings. Both traits contribute to ultimate grain yield. Cross CB-212 x LR-02 possess highest value of SCA for days taken for anthesis. CB-219 x LR-1 and CB-214 x LR-02 are good specific combiners for days to maturity and grain weight per spike. It is expected that these cross combinations will yield transgressive segregates, but plant height is not a desirable character in wheat as plants tend to lodge due to wind and stormy conditions. The proportion contributed by Lines X Tester and their interaction to the total variance are showed in Table-2.

As it is revealed from Table-2 that major contribution to the variance of plant height, tillers per plant, days to 50 % maturity, days to anthesis, days to maturity and grain weight per spike is made by lines (female parent). The interaction Lines X Tester only contributes 10.06, 19.65 and 15.90 to the tillers per plant, days to anthesis and grain weight per spike. Estimates of variances due to GCA, SCA and GCA/SCA ratio indicates that traits under study are under control of additive gene action which is good for selection and varietal development. Better SCA combination might include two good general combiners, two poor combiners may produce a good SCA combination due to epistatic interaction, but such combination are of no use as they will not produce transgressive segregates. Such combinations can be used in breeding programs of cross pollinated and vegetative propagating crops.

Table 2: Mean squares of Plant height, Tillers/Plant, Days to 50% Heading, Days to Anthesis, Days to Maturity, Grains Weight per Spike

SOV	df	Plant height	Tillers per Plant	Days to 50% Heading	Days to Anthesis	Days to Maturity	Grains wt. per Spike
Rep	2	26.84	13.54	3.43	17.7	39.078	0.0058
Treat	16	1695.18	50.23	229.937	145.32	309.085	0.1063
Parent	6	1230.6	86.41	327.85	229.71	483.19	0.003
Cross	9	440.107	18.25	176.53	96.033	217.63	0.1101
Lines	4	958.1167	35.53	393.78	169.95	470.55	0.207
Tester	1	73.633	5.63	0.133	14.7	0.3	0.0267
Error	32	14.07	4.65	8.3064	19.89	20.5159	0.269
Variance due to GCA		19.67	0.65	7.99	2.47	9.165	0.033
Variance due to SCA		-1.6117	-0.55	-2.47	3.96	-2.83	-0.0011
GCA/SCA		-12.2045	-1.18182	-3.23482	0.623737	-3.23852	-30

Table 3: Specific Combining ability effects of crosses developed

Cross	Plant Height	Tillers per Plant	Days to 50% Heading	Days to Anthesis	Days to Maturity	Grains wt. per Spike
CB-35 x LR-1	2.07	0.07	-0.43	-1.2	-1.9	0
CB-35 x LR-2	-2.07	-0.07	0.43	1.2	1.9	0
CB-212 x LR-1	0.57	1.07	0.07	-3.7	1.6	-0.02
CB-212 x CB-212	-0.57	-1.07	-0.07	3.7	-1.6	0.02
CB-214 x LR-1	-0.27	-1.27	-0.93	2.8	-1.4	0.13
CB-214 x LR-2	0.27	1.27	0.93	-2.8	1.4	-0.13
CB-219 x LR-1	-2.1	0.07	0.23	2.3	2.1	-0.02
CB-219 x LR-2	2.1	-0.07	-0.23	-2.3	-2.1	0.02
Miraj-08 x LR-01	-0.27	0.07	1.07	-0.2	-0.4	-0.09
Miraj-08 x LR-02	0.27	-0.07	-1.07	0.2	0.4	0.09

Table 4: General combining ability of Genotypes

Parents	Plant Height	Tillers per Plant	Days to 50% Heading	Days to Anthesis	Days to Maturity	Grains wt. per Spike
CB-35	-5.13**	1.53 ns	2.97*	-1.2ns	0.9ns	0.12ns
CB-212	-14.3**	2.53 *	9.47**	3.3ns	10.4**	0.07ns
CB-214	-6.47**	0.87 ns	3.47*	5.8*	5.4*	-0.33**
CB-219	9.03**	-1.47 ns	-4.37**	0.3ns	-4.1ns	0.04ns
Mairaj-08	16.87**	-3.47 **	-11.53**	-8.2**	-12.6**	0.11ns
LR-1	-1.57ns	0.43 ns	-0.07ns	0.7ns	-0.1ns	0.01ns
LR-2	1.57ns	-0.43 ns	0.07ns	-0.7ns	0.1ns	-0.01ns

Presence of variability within breeding material is pre-requisite for a successful breeding program. Estimates of variances for genotypes give measure of variability present for traits under study (Ijaz *et al.,* 2013) [4]. All genotypes exhibit variability for traits under study. Heterosis estimates of morphological and physiological characters is attributed by both additive and non-additive gene action. Additive gene action is required for variety development especially in self-pollinated crops except for hybrid development that may give transgressive segregates. Line x Tester matting design allows to differentiate between different form of gene action. Combining ability analysis shows that estimates of variances due to GCA (σ^2GCA**)**, SCA (σ^2SCA) and σ^2g / σ^2showed that σ^2GCA was greater than σ^2SCA for all traits except days to 50% heading, days to anthesis and grain weight per spike. This indicates predominantly additive gene effects for these traits (Ijaz *et al.,* 2013, Khaliq *et al.,* 2016) [4, 5]. Singh and Parasad (2000) [11] also reported high contribution of general combining ability in genetic control of characters in bread wheat. The cross CB-214 x LR-02 possess high SCA for tillers per plant and days to 50% headings which are associated with grain yield. CB-219 x LR-1 and CB-214 x LR-02 are good specific combiners for days to maturity and grain weight per spike. These combinations are expected to produce transgressive segregates which can be projected for selection of desirable genotypes Masood and Kronstad (2000) [9].

Conclusion

GCA and SCA estimates give idea about genetic architecture of the characters under study. Six genotypes CB-35, CB-212, CB-214, CB-219, Miraj-2008 were used as female parents. Genotypes LR-01 and LR-02 were used as male parents (testers) design. Line x Tester used in order to estimate the combining ability and genetic components for its important traits. Genotype Miraj-2008 shows good general combiner for traits under study. Results indicate that most of the yield associated traits are under control of additive- genes. The cross-combination CB-214 x LR-02 exhibit good SCA for number of tillers per plant and days to 50% headings. Both traits contribute to ultimate grain yield. CB-219 x LR-1 and CB-214 x LR-02 are possess high SCA for days to maturity and grain weight per spike therefore these two combinations can be used to produce transgressive segregates.

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