

Combining Ability Analysis for Yield and Yield Contributing Traits in Bread Wheat

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ABSTRACT

A 5 x 5 diallel cross involving wheat varieties LU-26S, 18172, 27HTN/1-54, DSN-5 and 243-1, was evaluated for general combining ability (GCA), specific combining ability (SCA) and reciprocal effects for various yielding traits like, flag leaf area, number of tillers per plant, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight and grain yield per plant. The study revealed that variance of components attributable to GCA, SCA and reciprocal effects were highly significant for all the characters studied. The GCA mean squares were larger than those of SCA for all characters except number of tillers per plant, number of grains per spike and 1000-grain weight. The higher magnitude of SCA than GCA for characters indicated that non-additive type of gene action was involved for the expression of the characters. Genotype 243-1 was better general combiner for flag leaf area, tillers per plant, number of grains per spike and 1000-grain weight. Most of the crosses showing desirable significant SCA effects involved non-additive type of gene action.

Key Words: Bread wheat; Combining ability; Diallel

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) defined combining ability and divided it in to general and specific combining ability. Combining ability analysis developed by Griffing (1956) has been extensively used to derive such information in F₁ generation. Its method I, and model I is the best in that it also gives the information for the effects of reciprocals. Singh *et al.* (1980), Bajwa *et al.* (1986), Malik *et al.* (1988) and Sattar *et al.* (1992) reported the both general and specific combining ability variances were highly significant for most of the characters indicating additive and non-additive type of gene action. While Mohy-ud-din and Shahzad (1998) and Khan and Ali (1998) reported significant general combining ability (GCA) variances for most of the characters. In addition, this analysis provides the nature and magnitude of various types of gene actions involved in the expression of qualitative and quantitative traits.

The breeders are often facing problems of selecting those parental lines, which in different cross combinations can furnish higher frequency of most desirable segregants. To achieve this goal, knowledge of prepotency of parental lines for combining ability is very useful in selection of

desirable lines. Most of the reports on combining ability analysis aimed at extracting as much basic genetic information as possible, and not specifically designed to apply the analysis in identifying crosses with superior performance for use in practical wheat breeding programme. Therefore the present study was undertaken to estimate the general and specific combining ability for yield and yield contributing traits in some wheat crosses. This information could be of great value for a successful wheat breeding programme to develop high yielding wheat genotypes.

MATERIALS AND METHODS

The present research work on combining ability studies for various plant characters was carried out in the experimental area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The experimental material comprised of five varieties/lines of bread wheat (*Triticum aestivum* L.) viz., LU-26S, 18172, 27HTN/1-54, DSN-5, 243-1. The five parental lines along with their hybrids and reciprocals were planted in Randomized Complete Block Design with three replications. The hybrid seed including reciprocals and parents was sown in the field during crop season 2002-03, using the randomized complete block design with three replications. Each replicate had 25 lines and each line was 5-meter long. The plant-to-plant and row-to-row distance was 15 and 30 cm, respectively. The sowing was done by using a dibble. Two seeds per hole were sown which were thinned to single seedling per site after germination to ensure good plant stand. At the time of maturity 10 guarded plants from each line were selected at random and the data

were collected for the traits like flag leaf area, number of tillers per plant, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight and grain yield per plant. The means were used for statistical analysis in each case following Steel and Torrie (1980). The characters showing significant genotypic differences were further subjected to combining ability analysis using Griffing (1956) Method I, Model I.

RESULTS AND DISCUSSION

The differences among the genotypes were highly significant for all the characters studied (Table I). The variances for general combining ability (GCA), specific combining ability (SCA) and reciprocal combining effects were also highly significant (Table III).

Mean performance of the parents and their hybrids revealed that among the parents 18172 showed maximum values for flag leaf area, number of spikelets per spike, number of grains per spike, 1000-grain weight and yield per plant, while for the spike length parent 243-1 showed the

maximum value (Table II). Flag leaf area ranged from 25.33 to 35.61 in hybrid combinations. Cross 27HTN/1-54 x 243-1 gave maximum value for flag leaf area, 243-1 x 27HTN/1-54 for tillers per plant and number of grains per spike, 18172 x 243-1 for spike length, 18172 x DSN-5 for number of spikelets per spike, DSN-5 x 243-1 for 1000-grain weight and for yield per plant.

The variances for GCA, SCA and reciprocal effects were highly significant for all the characters studied (Table III). The GCA variances for flag leaf area, spike length, number of spikelets per spike and grain yield per plant were higher than SCA indicating an additive type of gene action, while GCA variance for tillers per plant, number of grains per spike and 1000-grain weight were lower than SCA indicating the non-additive type of gene action. These results were in agreement with the findings of Mohy-ud-din and Shahzad (1998), Ali and Khan (1998), Masood and Kronstard (2000) and Mahmood and Aslam (2002) and Chowdhry *et al.* (1999).

For flag leaf area and grain yield per plant of 18172 had the highest GCA followed by 243-1. LU-26S was a

Table I. Analysis of variance for yield and yield contributing traits in a 5 x 5 diallel cross of wheat

Source of variation	D.F	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
Replications	2	14.07	3.91	0.28	0.32	12.42	21.45	27.81
Genotypes	24	29.59**	6.02**	1.24**	3.008**	139.66**	92.52**	39.62**
Error	48	5.91	2.87	0.12	0.22	72.32	11.85	16.34

* = Significant at P < 0.05

** = Significant at P < 0.01

NS = Non-significant

Table II. Mean values for yield and yield contributing traits of wheat genotypes used in a 5 x 5 diallel cross

Varieties/Genotypes	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
LU-26S	24.51	10.73	13.32	20.63	55.26	32.80	21.00
18172	32.68	12.06	13.08	22.50	58.90	36.46	25.33
27HTN/1-54	30.02	12.46	12.69	19.56	51.96	30.06	20.88
DSN-5	29.65	10.60	12.52	20.76	49.73	28.73	20.74
243-1	31.77	15.83	14.87	22.43	55.16	34.86	23.32
LU-26S x 18172	27.57	12.03	13.68	22.50	55.76	33.80	21.65
LU-26S x 27HTN/1-54	25.33	12.16	12.53	21.46	54.26	33.53	21.19
LU-26S x DSN-5	25.43	12.60	13.26	21.56	53.26	32.20	22.63
LU-26S x 243-1	31.91	11.46	14.39	21.86	55.26	32.33	21.94
18172 x LU-26S	33.91	10.50	13.85	21.36	54.13	35.66	23.52
18172 x 27HTN/1-54	34.88	11.53	14.01	22.53	55.16	35.00	23.35
18172 x DSN-5	32.53	11.60	14.22	23.83	54.00	37.06	24.32
18172 x 243-1	34.62	12.73	14.72	22.70	60.66	42.33	26.57
27HTN/1-54 x LU-26S	31.51	10.46	13.11	21.40	51.70	30.86	20.33
27HTN/1-54 x 18172	31.07	8.900	13.79	22.20	55.76	35.80	19.32
27HTN/1-54 x DSN-5	33.70	12.13	13.40	22.06	53.53	34.46	21.83
27HTN/1-54 x 243-1	35.61	12.33	14.21	22.33	53.06	35.44	23.19
DSN-5 x LU-26S	26.66	12.86	13.54	20.66	49.06	29.40	18.84
DSN-5 x 18172	32.70	10.93	14.48	23.76	56.36	34.26	21.66
DSN-5 x 27HTN/1-54	32.14	11.83	12.54	22.16	48.63	30.26	18.10
DSN-5 x 243-1	29.81	13.46	13.75	22.80	57.33	42.86	27.18
243-1 x LU-26S	32.95	10.73	13.53	22.40	56.43	39.03	25.44
243-1 x 18172	28.83	10.80	13.46	22.16	58.03	41.17	26.32
243-1 x 27HTN/1-54	34.43	13.56	14.54	22.50	64.13	40.60	30.21
243-1 x DSN-5	31.39	11.24	13.82	22.10	51.26	32.11	22.71

Table III. Combining ability analysis for yield and yield contributing traits in a 5 x 5 diallel cross of wheat

Source of variation	of D.F	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
GCA	4	115.84**	16.84**	4.57**	13.55**	316.02**	228.16**	133.60**
SCA	10	46.27**	17.17**	3.65**	6.56**	573.68**	377.85**	131.60**
Reciprocal effects	10	74.67**	14.15**	1.72**	3.95**	227.64**	134.20**	51.87**
Error	48	1.97	0.96	0.04	0.07	24.11	3.95	5.44

* = Significant at P < 0.05

** = Significant at P < 0.01

NS = Non-significant

Table IV. Estimates of general combining ability for yield and yield contributing traits in a 5 x 5 diallel cross of wheat

Genotypes	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
LU-26S	-2.60	-0.47	-0.24	-0.78	-2.51	-0.53	-0.92
18172	1.63	-0.32	0.16	0.15	1.15	-0.32	2.45
27HTN/1-54	0.34	-0.38	-0.25	-0.23	3.22	-0.54	-1.43
DSN-5	-0.65	0.08	-0.19	0.82	-3.36	-2.56	-1.55
243-1	1.28	1.09	0.52	0.04	1.50	3.95	1.45

Table V. Estimates of specific combining ability for yield and yield contributing traits in a 5 x 5 diallel cross of wheat

Crosses	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
LU-26S x 18172	0.38	-0.64	0.007	0.24	0.056	-2.18	-0.67
LU-26S x 27HTN/1-54	-0.65	0.47	-0.18	0.11	-2.98	-0.49	0.38
LU-26S x DSN-5	-2.03	1.42	0.11	-0.75	-2.71	0.61	0.48
LU-26S x 243-1	2.41	-1.23	0.005	0.54	1.11	1.49	-1.31
18172 x 27HTN/1-54	0.056	-1.28	0.30	0.11	1.33	3.50	1.09
18172 x DSN-5	0.41	0.25	0.26	-0.29	-6.23	1.28	-3.91
18172 x 243-1	0.67	0.67	0.29	0.08	4.00	1.57	4.77
27HTN/1-54 x DSN-5	2.57	0.13	0.65	-0.008	11.83	0.20	-1.00
27HTN/1-54 x 243-1	-0.35	-0.85	-0.17	0.10	0.07	1.91	0.51
DSN-5 x 243-1	-0.97	-0.53	-0.24	-0.74	-1.60	6.33	1.32

Table VI. Estimates of reciprocal effects for yield and yield contributing traits in a 5 x 5 diallel cross of wheat

Crosses	Flag leaf area (cm ²)	No. of tillers per plant	Spike length (cm)	No. of spikelets per spike	No. of grains per spike	1000-grain weight (g)	Grain yield per plant (g)
LU-26S x 18172	-3.16	-0.23	-0.3	0.57	1.32	-0.43	-0.93
LU-26S x 27HTN/1-54	-3.08	0.85	-0.07	0.03	1.78	-2.17	1.43
LU-26S x DSN-5	-0.61	-0.13	-0.19	-0.05	3.1	1.40	1.90
LU-26S x 243-1	-0.52	0.37	0.43	-0.27	-0.58	3.15	0.5
18172 x 27HTN/1-54	1.90	0.82	0.11	0.17	1.7	-0.90	2.62
18172 x DSN-5	0.19	-0.12	0.34	0.83	6.68	4.4	1.61
18172 x 243-1	0.095	-0.42	-0.088	0.1	-1.73	4.87	-1.82
27HTN/1-54 x DSN-5	0.50	0.60	-0.54	-0.85	4.08	0.10	1.09
27HTN/1-54 x 243-1	3.39	0.77	0.37	0.083	2.51	1.42	0.93
DSN-5 x 243-1	-0.79	1.11	-0.03	0.35	5.03	-2.12	2.24

poor combiner and had a negative effect (Table IV). As for tillers per plant, spike length and 1000-grain weight. 243-1 had the highest positive values. Parent DSN-5 had the highest positive value for number of spikelets per spike. 27HTN/1-54 had the highest positive value for number of grains per spike.

The SCA effects for yield and its contributing trait

studied in F₁ depicted that the cross 27HTN/1-54 x DSN-5 had the highest positive values for flag leaf area, spike length and for number of grains per spike (Table V). High SCA effects for tillers per plant were found in the cross LU-26S x DSN-5. For number of spikelets per spike LU-26S x 243-1 showed the maximum positive value. For 1000-grain weight DSN-5 x 243-1 and for grain yield per plant 18172 x

243-1 showed the highest positive values for specific combining ability effects. These results were in good agreement with those of Masood and Kronstad (2000) and Mahmood and Aslam (2002).

As regards the estimates of reciprocal effects in F_1 genotypes for yield and yield contributing traits 27HTN/1-54 x 243-1 showed the highest positive value for flag leaf area and tillers per plant (Table VI). In case of spike length the cross LU-26S x 243-1 showed the highest positive value. The cross 18172 x DSN-5 showed the highest positive reciprocal effects for number of spikelets per spike and number of grains per spike. The highest reciprocal effects for 1000-grain weight indicated by the cross 18172 x 243-1 while for grain yield per plant cross 18172 x 27HTN/1-54 showed the highest positive value for the reciprocal effects. These results are in accordance with the findings of Mohy-ud-din and Shahzad (1998) and Chowdhry *et al.* (1999).

CONCLUSIONS

It was concluded that parent 243-1 had better GCA for tillers per plant, number of grains per spike and for 1000-grain weight whereas parent 18172 for flag leaf area and grain yield per plant. These two parents can be used in hybridization programme for obtaining desirable combinations. The high SCA for flag leaf area, spike length and for number of grains per spike showed by the cross 27HTN/1-54 x DSN-5. For grain yield per plant 18172 x 243-1 showed the highest positive values for specific combining ability effects. Since high SCA effects in these two crosses for yielding traits like flag leaf area, spike length, number of grains per spike and grain yield per plant, the selection pressure on these yielding components in subsequent generations will result in higher yield. As the variance due to general combining ability was higher than specific combining ability for most yielding traits under study, appears to be logical that selection may well be focused on all the traits under study for maximum genetic gain.

REFERENCES

- Ali, Z. and A.S. Khan, 1998. Combining ability studies of some morpho-physiological traits in bread wheat (*Triticum aestivum* L.). *Pakistan J. Sci.*, 35: 1-4
- Bajwa, M.A., A.H. Shah., A.G. Asi and A.G. Khan, 1986. Heterosis and combining ability studies in durum wheat. *Rachis*, 5: 42-6
- Chowdhry, M.A., G. Rabbni, G.M. Subhani and I. Khaliq, 1999. Combining ability studies for some polygenic traits in *aestivum* spp. *Pakistan J. Biol. Sci.*, 2: 434-7
- Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian J. Boil. Sci.*, 9: 463-9
- Khan, A.S. and Z. Ali, 1998. General and specific combining ability estimates for plant height and some yield components in wheat. *Pakistan J. Agric. Sci.*, 35: 4-7
- Mahmood, N. and M.A. Chowdhry, 2002. Ability of bread wheat genotypes to combine for high yield under varying sowing conditions. *J. Genet. Br.*, 56: 119-25
- Malik, A.J., A.R. Chaudhry, M.M. Rajput and K.A. Siddqui, 1988. General and specific combining ability estimates in spring wheat diallel crosses. *Pakistan J. Agric. Res.*, 9: 10-5
- Masood, M.S. and W.E. Kronstad, 2000. Combining ability analysis over various generations in a diallel cross of bread wheat. *Pakistan J. Agric. Res.*, 16: 1-4
- Mohy-ud-din, Z. and K. Shahzad, 1998. Combining ability for some physiological and yield contributing traits in spring wheat (*Triticum aestivum* L.). *J. Agric. Res.*, 36: 1-6
- Sattar, A., M.H. Chaudhry, K.N. Shah and S.B. Khan, 1992. Combining ability estimates in five wheat varieties. *Pakistan J. Agric. Res.*, 13: 301-5
- Sheikh, S. and I. Singh, 2000. Combining ability analysis in wheat plant characters and harvest index. *Int. J. Trop. Agric.*, 18: 29-37
- Singh, K.P., C.S. Tyagi, S. Dalvir and V.P. Singh, 1980. Combining ability analysis in wheat. *Indian J. Agric. Res.*, 14: 247-53
- Sprague, G.G. and L.A. Tatum, 1942. General versus specific combining ability in cross of corn. *J. American Soc. Agron.*, 34: 923-32
- Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics. A Biometrical Approach*. McGraw Hill Book Co., New York

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