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Combining Ability Studies for Polygenic Characters in *Aestivum* Species

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ABSTRACT

Combining ability of some polygenic characters was studied in a set of diallel cross involving five varieties. Mean squares for general combining ability (GCA) and specific combining ability (SCA) were significant. Reciprocal effects were also found to be significant for plant height, spike length, spikelets per spike, 1000-grain weight and grain yield per plant but non-significant for peduncle length. The magnitude of SCA variance was greater than GCA variance for all the characters indicting that non-additive type of gene actions were important for all the characters. The prominent genotypes, 4943 and 4072 had high GCA effects, therefore, they could be exploited in the further breeding program.

Key Words: Wheat; Yield; Combining ability

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop of the world. It is the staple food and major source of calories and other valuable nutrients of a majority of people in Pakistan. An immense deal of research work on the study of combining ability of different plant characters of wheat has been carried out (Yadav & Mishra, 1992; Larik *et al.*, 1995; Mann & Sharma, 1995; Mishra *et al.*, 1996; Ali & Khan, 1998; Mohyuddin & Shahzad, 1998; Shahzad *et al.*, 1998; Chowdhry *et al.*, 1999).

The researchers and geneticists have always been making efforts to improve wheat production through genetic manipulations. This paper reports results of combining ability studies for polygenic characters of different wheat species.

MATERIALS AND METHODS

The experiment was conducted in the experimental area of Department of Plant Breeding & Genetics, University of Agriculture, Faisalabad. The experimental material comprised of five varieties/lines of bread wheat viz. Punjab 091, LU31, 4943 and 4072. These genotypes were planted in the field during rabi season of 1997-98 and crossed in a diallel fashion in all possible combinations. Parents and their hybrids (including reciprocals) were sown in the field on November 1998, using the randomized complete block design with three replications. Each replication consisted of 25 lines each of 5 m length. The plant to plant and row to row distance were 15 and 30 cm, respectively. Two seed per hole were sown with the help of a dibble and thinned to single healthy seedling per site after germination to ensure good plant stand. At the time of maturity 10 guarded plants were selected form each line at random and data were recorded for the plant height (cm), peduncle length (cm), spikelets per spike, 1000-grain weight (g) and grain yield per plant (g). The data collected were subjected to analysis of variance (Steel & Torrie, 1984). The characters, which showed significant differences among genotypes were further subjected to combining ability analysis according to Method I Model I (Griffing, 1996).

RESULTS AND DISCUSSION

Plant height. The analysis of variance of plant height (Table I) showed highly significant differences among the genotypes. The combining ability analysis yielded highly significant mean squares for general (GCA) and specific combining abilities (SCA). Reciprocal mean squares were also highly significant. The results also indicated that GCA mean squares were greater than those of SCA and reciprocal mean squares. The highest positive GCA effects for plant height were exhibited by variety 4943 with a value of 4.94 followed by 4072 (2.95) and Inq. 91 (0.98). The highest negative effect for this character was, however, shown by variety LU31 with a value of 7.24. It was found that genotype 4943 may be useful for further breeding program for this character especially (Table II). SCA effects have been presented in Table II. It is obvious that cross namely LU31 x 4943 (8.34), Pb. 96 x 4943 (6.49) and Inq. 91 x 4943 (4.20) possess a reasonable values of SCA effects indicating that progenies of these crosses can yield more desirable segregates (Table II).

Reciprocal effects (Table III) indicated that highest positive value was 0.61, recorded for the cross Inq. 96 x Pb. 96. Estimates for components of variance e i.e., general, specific and reciprocal combining abilities for plant height were 21.08, 32.33 and 55.06, respectively (Table IV). Additive and non-additive gene actions are responsible for the expression of this character. These observations were in conformity with the findings of Yadav and Mishra (1992), Ali and Khan (1998), and Chowdhry *et al.* (1999).

Peduncle length. Analysis of variance for peduncle length

indicated that the differences among the genotypes were highly significant. Range of the peduncle length was observed as 28.8 to 39.7 cm. Combining ability analysis showed that GCA and SCA mean squares were highly significant. Reciprocal mean squared were also highly significant. The results also indicated that mean squares for GCA were greater than those of SCA mean squares. The estimates of GCA effects of parents and their corresponding standard error were calculated. The highest positive GCA effects for peduncle length was exhibited by Inqalab-91

Table I. Mean squares of some indicated traits in 5 x 5 diallel cross in wheat

SOV	df	Plant height	Peduncle length	Spike length	Spikelets per spike	1000–grain weight	Grain yield per plant
Replication	2						
Genotypes	24	319.30**	49.50**	3.00**	13.50**	28.20**	37.30**
GCA	4	222.70*	21.71*	0.88**	4.63**	10.40**	6.54**
SCA	10	48.28**	19.70**	0.96**	7.08**	7.57**	16.79**
Reciprocals	10	122.08**	11.05	1.03**	1.82**	10.80**	10.44**

Table II. General Combining Ability and specific combining ability effects for some indicated trails of the five parents and their direct crosses, respectively

Genotypes	Plant height	Peduncle length	Spike length	Spikelets per spike	1000–grain weight	Grain yield per plant
Parents						
Pb-96	–1.64	0.71	–0.33	–0.47	–1.38	–1.15
Inq-91	0.98	1.13	–0.20	–0.89	0.01	–0.17
LU31	–7.24	–2.58	0.37	–0.06	0.27	0.09
4943	4.94	0.46	0.24	0.81	1.44	1.11
4072	2.95	0.28	–0.07	0.53	–0.34	0.10
Hybrids						
Pb-96 x Inq-91	–0.44	0.29	0.45	–0.34	–1.10	–1.80
Pb-96 x LU31	1.05	–1.82	0.32	–0.46	–0.15	–0.65
Pb-96 x 4943	6.40	6.20	0.18	0.70	1.03	1.76
Pb-96 x 4072	–6.02	–3.05	–1.03	–1.15	–0.55	–2.78
Inq-91 x LU31	–4.18	–1.51	–0.58	–0.39	0.26	–0.17
Inq-91 x 4093	4.20	–0.13	0.44	0.23	0.61	0.63
Inq-91 x 4072	–1.46	–1.50	0.05	0.85	–0.41	–0.37
LU31 x 4943	–0.387	0.83	–0.15	–1.60	–0.31	–1.25
LU31 x 4072	8.34	2.87	–0.30	–1.70	–2.13	–1.23
LU31 x 4072	–2.82	–3.09	–0.40	–2.15	–2.83	–3.85

Table III. Reciprocal effects for some indicated traits of reciprocal crosses of five wheat genotypes

Crosses	Plant height	Peduncle length	Spike length	Spikelets per spike	1000–grain weight	Grain yield per plant
Inq-91 x Pb-91	0.607	-0.200	0.184	0.984	1.450	2.663
LU31 x Pb-91	-2.092	-3.250	0.200	0.683	0.634	0.507
4943 x Pb-91	-11.835	-3.350	-0.233	0.169	-0.017	0.075
4072 x Pb-91	-1.695	2.250	0.234	-1.167	0.117	-1.062
LU31 x Inq-91	-3.082	-0.783	-0.050	-0.362	-1.867	-0.432
4943 x Inq-91	-17.784	-4.600	-0.950	-2.122	-4.150	-5.457
4072 x Inq-91	-10.867	-1.450	1.617	0.735	2.367	2.402
4943 x LU31	-2.462	-1.867	0.200	-0.800	-2.417	-0.789
4072 x LU31	-3.565	-1.000	-0.333	-0.487	-1.450	-0.542
4072 x 4943	0.300	-0.137	1.150	0.477	4.150	2.660
S.E.	2.44	1.72	0.33	0.57	0.37	0.48

Table IV. Genetic components of variance for some indicated traits in 5 x 5 diallel cross of wheat

Components	Plant height	Peduncle length	Spike length	Spikelets per spike	1000–grain weight	Grain yield per plant
GCA	21.08	1.58	0.07	0.40	1.01	0.61
SCA	32.33	13.79	0.74	6.42	7.30	16.32
Reci.	55.06	2.57	0.41	0.58	5.26	4.99
O^2A	42.15	3.16	0.13	0.79	2.03	1.22
O^2D	32.33	13.79	0.74	6.42	7.30	16.32

(1.13) followed by Punjab-96 (0.70). The highest negative GCA effects for this trial were shown by LU31 (-2.58). The SCA effects are presented in the Table II. The cross Punjab-96 x 4943 possessed the highest SCA effects (6.21) followed by LU31 x 4072 (2.87).

Reciprocal effects were also calculated. The highest positive value was 2.25 obtained from the cross 4072 x Pb.96 (Table III). Estimates for components of variance due to general, specific and reciprocal effects for peduncle length were 1.58, 13.79 and 2.57, respectively (Table IV).

The above results indicated that best general combiner for peduncle length was Inq 91. The cross Pb.96 x 4943 is the best suited for this character, being best specific combiner. Both additive and non-additive type of gene action was involved for the expression of this trait. These findings fully coincide with the results of Khan and Ali (1998) i.e., specific combining ability for this trait was non-significant.

Spike length. Spike length is one of the important components of yield. Since longer spikes are expected to bear more spikelets per spike, grains per spike which finally results in better yielding ability. The analysis of variance for spike length indicated that differences among genotypes were highly significant. The expression of the character ranged form 11.4 to 12.9 cm. Combining ability analysis for spike length showed that general, specific and reciprocal mean squares are highly significant.

The highest positive general combining ability effects for spike length were recorded in LU31 (0.37) followed by 4943 (0.24). The highest negative effects for this character were, however, exhibited by Pb.96, where the calculated value was -0.33. For SCA, it was obvious that cross Inq.91 x 4943 possessed the highest positive SCA (0.44) for spike length (Table II). The highest positive reciprocal value (1.62) was observed in cross 4072 x Inq.91. Estimates for genetic components of variance regarding GCA, SCA and reciprocal effect were 0.07, 0.74 and 0.41, respectively. SCA variance was larger than GCA variance indicating that non-additive gene action was more important for the expression of this trait, though additive and non-additive gene action was also involved in the expression of this character. The results are in agreement with the results of Yadav and Mishra (1992), Khan and Ali (1998) and Shahzad *et al.* (1998).

Number of spikelets per spike. Number of spikelets per spike is one the important yield contributing characters in wheat. Analysis of variance for this character revealed that differences among genotypes were highly significant. The range of expression of this trait was 15.3 to 22.5 spikelets per spike. Combining ability analysis showed that GCA mean squares and SCA mean squares were highly significant while reciprocal mean squares for this character were significant.The highest positive GCA effects for number of spikelets per spike were exhibited by the genotype 4493 (0.82), while highest negative effects were observed in Inqalab-91 (-0.82). The cross Inqalab-91 x 4072 possessed the highest positive SCA effects (0.86) for this trait. The highest positive reciprocal value was 0.98 in the cross Inq 91 x Pb-96. Estimates for components of variance due to general, specific and reciprocal effects for spikelets per spike were 0.40, 4.62 and 0.58, respectively (Table IV).

In the light of above results, it is concluded that both additive and non-additive type of gene action is involved in the expression of this trait. Genotype 4943 is the best general combiner and the cross Inq-91 x 4072 has good specific value, which may yield transgressive segregates in the later generations to be selected for the improvement in spikelets per spike. SCA variance was greater than GCA variance indicating that non-additive type of gene action was more important.

These results are in close conformity with the findings of Yadav and Mishra (1992) and Mishra *et al.* (1996). Chowdhry *et al.* (1999) reported non-significant GCA and SCA effects for this character. Reciprocal effects, however, were significant.

1000-grain weight. Analysis of variance for 1000-grain weight revealed that differences among genotypes were highly significant (Table I). Expression of the character ranged form 45.03 to 52.27 g. The analysis of variance for combining ability (Table I) showed that GCA mean squares were highly significant, SCA and reciprocal mean squares were also highly significant.

The highest positive GCA for 1000-grain weight was exhibited by the genotype 4943 (1.44) followed by LU31 (0.28) while the hugest negative effects for this character were shown by the variety Pb.96 (-1.38). It was evident that two crosses (Pb.96 x 4943 and Inq.91 x 4943) possessed remarkable values of positive SCA effects. The highest positive reciprocal effects were observed in the cross 4072 x LU31 (4.15). Estimates of genetic components of variance i.e., general, specific and reciprocal combining ability for 1000-grain weight were 1.02, 7.21 and 5.27, respectively.

The above results provide the conclusion that the genotype 4943 was the best general combiner for this trait, while the best specific cross was Pb.96 x LU31. As the GCA and SCA mean squares were highly significant both additive and non-additive gene action were involved in the expression of this trait. These results are in conformity with the findings of Mishra *et al.* (1996), Ali and Khan (1998), Shahzad *et al.* (1998) and Chowdhry *et al.* (1999).

Grain yield per plant. Differences among genotypes under study were highly significant for grain yield per plant (Table I). Range of expression for this trait varied from 19.57 to 26.85 g. Combining ability analysis of variance (Table II) showed highly significant mean squares for GCA, SCA and reciprocal effects. It was further indicated that mean squares for SCA were greater than GCA mean squares.

Highest positive GCA effects were displayed by the genotype 4943 (1.12) followed by the genotype 4072. The highest negative effects were observed for variety Pb.96 (-1.15). The crosses Pb.96 x 4943 and Inq.91 x 4943 possessed reasonable SCA effects for grain yield per plant

(Table II). The highest positive reciprocal value was indicated in the cross Inq.91 x Pb.96 (2.67). Estimates of GCA, SCA and reciprocal variance were 0.61, 16.33 and 4.99, respectively.

Highly significant mean squares due to GCA and SCA displayed that grain yield per plant is influenced by both additive and non-additive genetic effects. However, GCA variance was smaller than SCA variance displaying the predominant role of non-additive genetic effects. The best general combiner for grain yield was found to be the genotype 4943 while the best specific cross combination was Pb.96 x 4943. These results get support from the findings of Yadav and Mishra (1992), and Mann and Sharma (1995).

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