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COMBINING ABILITY STUDIES IN SEVEN WHEAT VARIETIES

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ABSTRACT

Seven wheat varieties were crossed in a diallel fashion to study their behaviour in general and specific cross-combinations. Highly significant general and specific combining ability was observed for most of the characters under study, though specific combining ability for number of tillers per plant was non-significant. Additive genetic effects controlled the expression of plant height, number of days taken to earing, number of tillers per plant and number of spikelets per spike while both additive and non-additive gene actions affected the expression of number of kernels per spikelet. The variety 1050 was found to be the best general combiner.

INTRODUCTION

Wheat (*Triticum aestivum* L. em. thell), the most important cereal of Pakistan, has always attracted the attention of scientists to maximise grain production in the country. The sustained research efforts have led to the evolution of high-potential varieties, which have helped to increase wheat production in the country to the extent of self-sufficiency. In view of the increasing population the need to further accelerate efforts for continued genetic improvement of wheat is greater today than ever before.

The success of almost all the breeding programmes, depends upon the selection of potential parents to be utilized in the future hybridization programme. Good general and specific combining ability of the selected parents is, therefore, of immense importance to the plant breeder.

Estimates of general and specific combining ability for a number of wheat varieties have been reported by various workers. It has been observed that a

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large part of the total genetic variability for various characters of economic importance is linked with general combining ability, a measure of additive genetic variance. Significant specific combining ability effects designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved. It also measures non-additive genetic variance for certain characters. The present studies constitute a step towards finding potential parents from a combination of diallel crosses so as to augment the breeding programme on wheat.

MATERIALS AND METHODS

These studies were carried out in the year 1989-81. Seven wheat varieties viz Ak 141, Pb 8, C 591, Lu 26, Lu 61-4, 1050 and Olsen Dwarf were chosen to serve as experimental material. Diverse genotypes provided fairly broad range of variation for the characters under estimation. All possible crosses including reciprocals were made during 1979-80. F_1 's, reciprocals and parents were space planted according to completely randomized block design with four replications. A distance of 30 cm was kept between adjacent rows and 24 cm between plants. Different genotypes were assigned at random to the experimental plots in each block. To ensure good germination, two seeds per hill were dibbled and after germination excessive plants were thinned leaving one plant per hill before the application of first irrigation. The entire experiment received identical agronomic treatments during the period of growth. At maturity ten guarded plants were pulled out from each row in each block to record data on plant height, number of days taken to earing, number of tillers per plant, number of spikelets per spike and number of kernels per spikelet.

The data recorded were analysed to estimate general and specific combining ability effects, reciprocal effects and their respective variances. The mean values computed for each character were used for the analysis as by Griffing (1956) in Method 1, model I.

RESULTS AND DISCUSSION

Analysis of variance depicted highly significant genotypic differences for plant height, number of days taken to heading, number of tillers per plant, number of spikelets per spike and number of kernels per spikelet (Table 1). A perusal of the data revealed that mean squares due to general cembining ability were highly significant for four out five characters studied. Non-significant esimates appeared both for specific combining ability and reciprocal effects for the trait of number of tillers per plant.

Table 1. *Analysis of variance for the characters under study*

Source of variation	Degree of freedom	Mean squares				
		Plant height (cm)	No. of days taken to heading	No. of tillers per plant	No. of spikelets per spike	No. of kernels per spikelet
Replications	3	23.23	4.08	89.09	0.12	0.33
Crosses	48	2349.84**	44.34**	64.41**	3.61**	0.41**
Error	144	7.45	1.86	7.45	0.44	0.03
General combining ability	6	4362.10**	76.60	114.06**	4.31**	0.52*
Specific combining ability	21	84.33**	3.16**	2.00	0.59**	0.06**
Reciprocal effects	21	10.23**	1.15**	2.22	0.23**	0.03**
Error	144	1.86	0.46	1.86	0.11	0.01

*P=0.05; **P=0.01.

Highly significant general and specific combining ability for almost all the characters furnished an evidence of their control on the expression of each character. However, relative proportion of general combining ability for all the characters was much greater as compared to that of specific combining ability.

General combining ability effects can be considered as the numerical values assigned to parents in relation to their mean performance in cross-combinations. Estimates of general combining ability effects, for all the characters under study, presented in Table 2 indicated that four out of seven varieties manifested positive general combining ability effects for plant height and number of days taken to heading, while general combining ability effects for number of tillers per plant, number of spikelets per spike and number of kernels per spike were positive for three varieties. The greatest positive general combining ability effects for plant height (18.5382), number of days taken to heading (2.9028) and number of tillers per plant (5.7976) were shown by the variety Pb 8. Similarly, the variety 1050, presented the highest general combining ability effects for number of spikelets per spike and number of kernels per spikelet with values being + 0.9842 and + 0.2709, respectively.

Table 2. *Relative estimates of general combining ability effects*

Varieties	General combining ability effects				
	Plant height (cm)	No. of days taken to heading	No. of tillers per plant	No. of spikelets per spike	No. of kernels per spikelet
AK 141	+11.0789	−0.0322	+1.1797	−0.5033	−0.0490
Pb 8	+18.5382	+2.9028	+5.7976	−0.4125	−0.2712
C 591	+15.0510	+0.1463	+0.3347	−0.1515	−0.0376
LU 26	+ 1.5317	−3.8065	−1.6180	−0.4533	+0.1523
LU 61−4	−13.4468	+0.3428	−1.6444	+0.0628	−0.1826
1050	− 1.2604	+2.2713	−2.3752	+0.9842	+0.2709
Olsen	−31.4925	−1.8244	−1.6744	+0.4736	+0.1173
SE ($g_i - g_j$)	0.5157	0.2563	0.5160	0.1253	0.0354

Generaly, plant height is considered as an indirect component of yield. The highest negative general combining ability effect (31.4925) for plant height given by Olsen Dwarf indicated that it can enter in any breeding programme as a dwarfing gene source. Moreover, it was concluded from Table 2 that certain varieties would yield superior segregates for grain yield by effecting an individual or a combination of yield components brought together by virtue of cross-combinations. The variety Olsen Dwarf effectively decreased plant height, while Pb 8 significantly increased the number of days taken to heading and number of tillers per plant, whereas variety 1050 influenced positively number of spikelets per spike and number of kernels per spikelet. The discussion on various aspects of yield components suggested that the crosses between these promising genotypes might result in potential segregates with increased yield.

Relative estimates of specific combining ability effects for various agronomic characters under consideration are shown in Table 3 with their corresponding standard errors.

Out of 21 crosses, ten showed positive specific combining ability effects for plant height, nine for number of days taken to heading, ten for number of tillers per plant, 14 for number of spikelets per spike and 13 for number of kernels per spikelet. The highest positive and negative specific combining ability effects (+9.086 and −9.857) for plant height were obtained from the crosses C 591 x 1050 and C 591 x Olsen Dwarf, respectively. The cross-combinations C 591 x Lu 26 and 1050 x Olsen Dwarf possessed the greatest positive specific combining ability effects for number of tillers per plant (+1 864). Similarly, the highest positive specific combining ability effects for number of spikelets per spike and number of kernels per spikelet were noticed from the crosses Pb 8 x Olsen Dwarf and Ak 141 x Lu 61-4, respectively.

Reciprocal effects were estimated for plant height, number of days taken to heading, number of tillers per plant, number of spikelets per spike and number of kernels per spikelet. A perusal of data in Table 4 showed that the greatest positive reciprocal effect of + 8.210 for plant height was obtained from the cross-combinations C 591 x Lu 26, while the maximum negative effect of −3.700 was observed from cross C 591 x Lu 61-4.

The crosses Pb 8 x Lu 26 and C 591 x Lu 61-4 presented the highest positive reciprocal effects for number of days taken to heading and number of tillers per plant, respectively. Similarly, the greatest positive reciprocal effects for number of spikelets per spike and number of kernels per spikelet were shown by the crosses Lu 26 x Lu 61-4 and C 591 x Olsen Dwarf with the values

Table 3. *Relative estimates of specific combining ability effects*

Crosses	Specific combining ability effects				
	Plant height (cm)	Days taken to heading	Tillers per plant	Spikelets per spike	Kernels per spikelet
Ak 141 x Pb 8	−4.215	+1.253	+0.726	−0.563	−0.202
Ak 141 x C 591	−4.943	+1.009	+0.249	−0.236	−0.145
AK 141 x LU 26	+1.651	−0.413	+0.692	+0.103	+0.140
AK 141 x LU 61-4	+8.955	+0.563	+0.179	+0.677	+0.320
AK 141 x 1050	+5.553	−0.616	−0.380	+0.166	−0.004
AK 141 x Olsen*	+5.510	−1.395	−0.446	+0.376	+0.050
Pb 8 x C 591	−9.692	+1.449	+0.117	−0.264	−0.038
Pb 8 x LU 26	+5.417	−0.598	−0.670	−0.200	+0.007
Pb 8 x LU 61-4	+8.780	−1.247	−0.045	−0.279	+0.032
Pb 8 x 1050	+6.159	−0.676	−2.028	+0.400	+0.033
Pb 8 x Olsen*	+4.981	−2.080	+0.386	+0.973	+9.292
C 591 x LU 26	+3.454	+1.784	−0.568	+0.301	−0.107
C 591 x LU 61-4	−0.577	−1.366	+1.394	+0.060	−0.247
C 591 x 1050	+9.086	−0.794	+0.039	+0.539	+0.130
C 591 x Olsen*	−9.857	−1.698	−0.043	+0.337	+0.188
LU 26 x LU 61-4	−0.673	+1.212	+0.022	+0.625	+0.003
LU 26 x 1050	−1.357	−0.466	−0.503	+0.041	−0.085
LU 26 x Olsen*	−4.802	+0.379	−0.633	−0.511	+0.003
LU 61-4 x 1050	−5.181	−0.366	−0.466	+0.012	+0.145
LU 61-4 x Olsen*	−5.074	+1.355	−1.707	−0.939	−0.322
1050 x Olsen*	−6.325	+1.776	+1.864	+0.326	+0.020
SE ($S_{ij}-S_{ik}$)	1.2633	0.6279	1.2640	0.0943	0.0868
SE ($S_{ij}-S_{kl}$)	1.1532	0.3286	1.1539	0.2803	0.0793

*Dwarf

Table 4. *Relative estimates of reciprocal effects*

Crosses	Reciprocal effects				
	Plant height (cm)	Days taken to heading	Tillers per plant	Spikelets per spike	Kernels per spikelet
AK 141 x Pb 8	−0.375	−0.500	−0.875	+0.262	+0.005
AK 141 x C 591	−3.110	+0.000	+1.250	−0.375	+0.005
AK 141 x LU 26	−1.085	+0.275	−0.450	−0.212	+0.150
AK 141 x LU 61-4	−2.610	+0.550	−0.950	−0.212	−0.095
AK 141 x 1050	−0.875	+0.500	+0.930	+0.112	−0.025
AK 141 x Olsen*	−0.600	+0.125	−0.805	−0.212	−0.015
Pb 8 x C 691	−0.6.0	+0.375	+1.165	+0.087	−0.070
Pb 8 x LU 26	+0.440	+2.375	+1.075	+0.075	−0.135
Pb 8 x LU 61-4	+0.675	+0.875	+1.655	+0.287	+0.025
Pb 8 x 1050	+1.960	−0.375	+1.300	−0.262	+0.020
Pb 8 x Olsen*	−1.250	−0.125	−0.205	+0.100	+0.025
C 591 x LU 26	+8.210	+0.373	−0.065	−0.437	+0.145
C 591 x LU 61-4	−3.700	−0.500	+1.900	+0.237	−0.130
C 591 x 1050	−2.850	−0.750	−0.035	−0.012	−0.060
C 591 x Olsen*	−0.590	+0.250	−1.700	−0.150	+0.175
LU 26 x LU 61-4	+1.135	−0.875	+0.395	+0.550	+0.040
LU 26 x 1050	+1.015	−0.875	−0.590	+0.087	−2.095
LU 26 x Olsen*	+0.910	−0.375	−0.290	+0.025	+0.170
LU 61-4 x 1050	−0.665	−0.375	+0.120	−0.025	+0.170
LU 61-4 x Olsen*	−3.095	+0.100	−2.050	−1.162	−0.280
1050 x Olsen*	−0.325	−1.250	+0.220	−0.050	−0.045
SE (rij − rkl)	1.3645	0.6782	1.3653	0.3317	0.0938

*Dwarf.

being + 0.550 and 0.175, respectively. The cross Lu 61-4 x Olsen Dwarf displayed the highest negative reciprocal effect for number of tillers per plant, number of spikelets per spike and number of kernels per spikelet, whereas the greatest negative reciprocal effect for days taken to heading was shown by the cross-combination 1050 x Olsen Dwarf.

The proportion of the components of variance for general combining ability, specific combining ability and reciprocal effects in the variance provide an information about the relative preponderance of additive and dominance effects which affect the expression of various characters. From the per cent estimates of variance components (Table 5) it was evident that variance components of general combining ability were remarkably larger for all the characters except for number of kernels per spikelet, where both general and specific combining ability effects were equal. The relative proportion of general combining ability (85. 22%) for plant height was nearly six times greater than that of specific combining ability (13.10%). Likewise, the relative proportion of general combining ability for number of days taken to heading was much greater than the specific effects. Similarly, general combining ability accounted for 79.05 and 98.38 per ce t of the total variation compared to a meagre 0.79 and

Table 5. *Variance components for general combining ability, specific combining ability and reciprocal effects for the characters studied*

Variance	Plant height (cm)		Number of days taken to heading		Number of tillers per plant		Number of spikelets per spike		Number of kernels per spikelet	
	Component estimates (%)		Component estimates (%)		Component estimates (%)		Component estimates (%)		Component estimates (%)	
$1/6 \sum g_i^2$	305.69	85.22	6.25	69.17	8.00	79.05	25.65	98.48	0.03	37.50
$1/21 \sum_i \sum_j S_{ij}^2$	46.99	13.10	1.54	20.29	0.08	00.79	00.27	1.00	0.03	37.50
$1/21 \sum_i \sum_{<j} r_{ij}^2$	4.18	1.16	0.34	4.48	0.18	1.78	00.06	0.22	0.01	12.50
σ^2	1.86	0.52	0.46	6.06	1.86	18.38	00.11	0.40	0.01	12.50

1.00 per cent from specific combining ability effects for number of tillers per plant and number of spikelets per spike, respectively. Unlike other characters under study, both general and specific combining abilities were found to be equally important for number of kernels per spikelet.

Under the assumptions of (i) normal diploid segregation, (ii) absence of maternal effects, (iii) independent action of non-allelic genes, (iv) no multiple alleles (v),homozygous parents, (vi) gene independently distributed between the parents, and (vii) inbreeding coefficient equal to one (Griffing, 1956), it was concluded that the differences in general combining ability were due to additive genes and the diffirences in specific combining ability and reciprocal effects resulted due to non-additive gene effects. Keeping in view the above facts the perusal of Table 5 revealed that the characters such as plant height, number of days taben to heading, number of tillers per plant and number of spikelets per spike were under the controll of additive gene effects while both additive and non-additive genetic effects controlled the expression of number of kernels per spikelet. These results are in agreement with the findings of Brown *et al.* 1966. Gyawali *et al.*, 1968; Bitzer and Fu, 1972; Sattar, 1972; Widner and Lebsock, 1973; Sadiq *et al.*, 1977; and Chowdhry *et al.*; 1980. Since additive gene action affected most of the yield components, it was suggested that selection for superior segregates would need to be practised in early segregating generations.

REFERENCES

Bitzer, M. J. and S. H. Fu. 1972. Heterosis and combining ability in southern soft red winter wheat. Crop. Sci. 12 : 35-37.

Brown C., M. R. O. Weible and R. D. Seif. 1966. Heterosis and combining ability in common winter wheat. Crop. Sci. 6 : 282-283.

Chowdhry, A. R. M. A. Chowdhry and B. Ahmad. 1980. Combining ability analysis of our wheat varieties. Pak. J. Agri. Sci. 17 (3-4) : 5-14.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol. Sci. 9 : 463-493.

Gyawali, K.K., C.O. Gualset and W. T. Yamazaki. 1968. Estimates of heterosis and combining ability in winter wheat. Crop Sci 8 : 322-324.

Sadiq, M.S., A. Shakoor and M. Yousaf. 1977. Combining ability analysis in a diallel set involving seven wheat varieties mutant lines. Pak. J. Agri. Sci. 14 (2-3) : 53-60.

Sattar, A. 1972. Heterosis and combining ability studies in *Triticum aestivum* L. M.Sc. Thesis, WPAU, Lyallpur.

Widner, J. N. and K. L. Lebsock. 1973. Combining ability in durum wheat. Crop Sci. 13 : 164-167.