IMPLICATION OF COMBINING ABILITY: ANALYSIS OF SOME CHARACTERISTICS OF SPRING WHEAT

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ABSTRACT

Analysis of combining ability was performed in a complete set of diallel for six plant-characters, to determine the prepotency of fivewheat cultivars. Mean-squares for general combining ability and specific combining ability were highly significant, for: days to maturity; plant height; spike length; number of spikelets/spike; weight of 100 grains and grain-yield/ plant. The proportion of variance-components, due to specific combining ability was greater than that of general combining ability for: grain-yield; weight of 100 grains; spike length; spikelets/spike; and maturity period, which indicated the preponderance of non-additive type of gene-action for these characters. However, the inheritance of plant-height was shown to be conditioned by genes acting additively.

The comparison of parents revealed that Shalimar-88 was a better general combiner for grain-yield and weight of 100 grains, while Blue-Silver and Sutlej-86 performed as better parents for plant-height. The performance of parental lines in their specific cross-combinations suggested that Barani-83 x Pirsabak-91; Blue-Silver x Pirsabak 91 and Blue-Sliver x Sutlej-86 expressed their superiority as specific combiners for grain-yield and for at least one yield component. These crosses may be utilized extensively in future breeding.

Key words: Wheat (Triticum aestivum L.), Diallel cross, Genetic analysis, Combining ability, Yield-related characters.

INTRODUCTION

Wheat is a major staple food of the people of Pakistan and is cultivated throughout the country. Ever since the introduction of short-statured and fertilizer-responsive varieties, a great deal of research work has been done in the domain of wheat-breeding. The breakthrough is not sufficient, due to changing circumstances in the country, such as alarming increase in population, smuggling of wheat and its proper export. This necessitates that breeders should further boost the per-unit-productivity of this vital cereal. Knowledge about genetic mechanism, involved in the expression of yield-related traits, is helpful in developing superior genotypes. The information about the relative contribution of components of variation i.e., additive, non-additive and epistasis, is essential for effective plant-improvement exercise (Azhar and Ajmal, 1999). Among various techniques, genetic analysis formulated by Griffing (1956), provides a workable approach, to evaluate newly developed cultivars for their parental usefulness and to assess the gene- action involved in various attributes, so as to design an efficient breeding-plan, for further genetic upgrading of the existing material.

In literature, both additive and non-additive genetic systems, controlling grain-yield and yield-relating traits in wheat, have been reviewed. Asad et al. (1992), Mishra et al. (1994), Patil et al. (1996) and Rajara and Maheshwari (1996) reported that the major part of genetic variation for yield and its components were conditioned due to non-additive genetic effects. However, the manifestation of genetic variation for yield-relating characters has been indicated under the control of additive type of gene-action by Khan et al. (1991), Kalwar et al. (1993), Chaudhry et al. (1994) and Ajmal et al. (2000). The present research was carried out in order to generate genetic information regarding general and specific combining ability, and to find out better general combiners and best cross-combinations for more grain-yield.

MATERIALS AND METHODS

The present investigations were conducted in the experimental area of Department of Plant Breeding and Genetics, University of Arid Agriculture, Rawalpindi. The experimental material comprised five varities of wheat viz Barani-83, Blue-Silver, Sutlej-86, Shalimar-88 and Pirsabak-91. The crosses were made among the parental lines, in complete diallel fashion in March, 1998. Proper care was taken to avoid contamination of genetic material during hybridization. The seeds of F1s along with their parents were sown in randomized complete block-design, with three replications during November, 1998. Each plot comprised five-meter long single row, while row-to-row spacing was kept as 30 cm.

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The data from the ten plants, were recorded at maturity earmarked in each row for plant-height, days to maturity, spike length, number of spikelets/spike, weight of 100 grains and gain-yield/plant. The data was analysed according to the analysis of variance techniques, as outlined by Steel and Torrie (1980), to determine the significant differences among genotypes for all the characters. The diallel analysis for these traits was computed according to Griffing's approach, method-I of model-I (Griffing, 1956).

RESULTS AND DISCUSSION

The results of the analysis of variance, presented in Table-1, revealed that highly significant differences occurred among F1 progenies and their parental lines, for all the six characters.

The total genetic variability, existing in each character, was partitioned into attributable components, i.e. general and specific combining-ability effects ('gca' and 'sca', respectively) as suggested by Sprague and Tatum (1942), and reciprocal effects as outlined by Griffing (1956).

Analysis of combining-ability (Table-2) depicted that mean-squares due to 'gca' and 'sca' were highly significant for all the characters under study. As far as the variances due to reciprocals are concerned, these were highly significant for plant-height and number of spikelets/spike, whereas it was non-significant for rest of the traits. Significant values of 'gca' and 'sca' mean-squares suggested the contribution of both additive and non-additive types of gene-action involved in the inheritance of these plant characters.

The estimates of general combining-ability effects (Table-3) revealed that, among all parental lines, Shalimar-88 attained the first position in ranking order for the manifestation of grain-yield. The same cultivar also possessed better magnitude of 'gca' effects for spike-length and weight of 100 grains.

The maximum 'gca' effects for early maturity and spike-length were noted in Barani-83. Sutlej-86 and Blue-Silver were observed as good general combiners for short stature of plant, with 'gca' effects of 3.196 and 3.076, respectively. Sutlej-86 also had better 'gca' effects for number of spikelets/spike. Wheat variety Pirsabak-91 exhibited best performance of 'gca' in the case of number of spikelets/spike and weight of 100 grains, but it was not a high combiner for grain-yield.

The estimates of specific combining ability effects and reciprocal effects for various plant-characters, based

Table - 1: Mean Squares for Days to Maturity, Plant Height, Spike Length, Spikelets/Spike, 100 Grain Weight and Grain Yield in a Diallel Cross of Five Wheat Varieties

Source of variation	Degree of freedom	Days to maturity	Plant-height (cm)	Spike-length (cm)	Spikelets spike^{-1} (number)	Weight of 100 grains (g)	Grain-yield plant^{-1} (g)
Genotypes	24	17.030**	222.755**	4.350**	24.590**	25.305**	15.914**
Repeats	2	0.573	1.651	0.476	5.023	4.447	2.174
Error	48	1.782	4.093	0.671	3.281	6.873	4.383

Note: ***significant at 1% level of probability.*

Table - 2: Mean Squares due to General Combining Ability, Specific Combining Ability and Reciprocals for Certain Yield Relating Characters in a Five Parental Wheat Diallel Cross

Source of variation	Degree of freedom	Days to maturity	Plant height (cm)	Spike-length (cm)	Spikelets spike^{-1} (number)	100 grain weight (g)	Grain-yield plant^{-1} (g)
General combining ability	4	10.614**	366.889**	2.933**	13.986**	17.231**	7.708**
Specific combining ability	10	8.978**	15.806**	1.886**	7.176**	8.709**	7.658**
Reciprocal effects	10	0.4	15.643**	0.421	6.900**	3.042	1.989
Error	48	0.594	1.364	0.224	1.094	2.291	1.461

Note: ***significant at 1% level of probability.*

Table - 3: Estimates of General Combining Ability Effects for Certain Yield-Relating Characters in Five Parental Diallel Cross of Wheat

Varieties	Days to maturity	Plant-height (cm)	Spike-length (cm)	Spikelets/spike (number)	100 grain weight (g)	Grain-yield $plant^{-1}$ (g)
Barani 83	-1.08	10.786	0.616	0.205	0.297	0.422
Blue Silver	-0.647	-3.076	0.486	0.005	-2.076	-1.157
Pirsabak 91	1.387	-2.773	0.468	1.979	1.122	-0.135
Sutlej 86	0.753	-3.196	0.296	1.07	0.387	0.33
Shalimar 88	-0.413	1.74	0.544	0.695	1.042	1.2

on the data from F1 hybrids of five wheat varieties are presented in Table-4.

Blue-Silver x Pirsabak-91 proved to be the best cross for days-to-mature, having higher magnitude of 'sca', i.e. 2.447. Crosses Barani 83 x Shalimar 88 and Pirsabak 91 x Sutlej 86, were observed as better specific hybrids for plant-height, possessing 'sca' values of 4.347 and 3.647, respectively. The highest specific combining ability effects for spike-length (0.390), were shown by Blue-silver x Shalimar-88, which was followed by Barani-83 x Blue-Silver (0.308). Hybrid Pirsabak-91 x Sutlej-86 surpassed all other direct crosses regarding number of spikelets/spike, with 2.079 'sca' value. As far as weight of 100 grains is concerned, the highest value for specific combining ability effects i.e. 2.778 was observed in Barani-83 x Sutlej-86, followed by 1.032 'sca' effects in Blue-Silver x Pirsabak-91. It is obvious from the results that Barani-83 x Pirsabak-91 was the best hybrid owing to the maximum 'sca' value (1.288) for grain-yield followed by cross Blue-Silver x Sutlej-86.

The data regarding reciprocal effects presented in table-4 revealed that the maximum reciprocal effects for early maturity were noted in the case of cross of Barani-83 x Pirsabak-91. Sutlej-86 x Shalimar-88 showed the higher reciprocal effects for the plants of short stature.

Table - 4: Estimates of Specific Combining Ability Effects and Reciprocal Effects (in parenthesis) for Certain Yield-Relating Characters in F_1 Hybrids of Five Parental Wheat Diallel Crosses

Crosses	Days to maturity	Plant-height (cm)	Spike-length (cm)	Spikelets/spike (number)	100 grain weight (g)	Grain-yield $plant^{-1}$ (g)
Barani 83 x Blue Silver	1.58 (-0.333)	1.9 -5.35	0.308 -0.367	0.382 (-2.950)	-3.958 (-1.385)	-0.117 (-1.532)
Barani 83 x Pirsabak 91	1.047 (-1.167)	-1.67 -4.65	-0.423 -0.32	0.982 -1.567	-0.268 (-0.117)	1.288 (-1.448)
Barani 83 x Sutlej 86	1.013 -0.5	-0.763 -4.033	-0.835 -0.643	-3.571 -1.267	2.778 -0.193	-0.635 (-0.693)
Barani 83 x Shalimar 88	-0.653 -0.001	4.347 -2.033	-1.095 -0.607	-0.558 (-3.033)	-2.065 (-0.140)	-1.59 -1.288
Blue Silver x Pirsabak 91	2.447 -0.333	0.6 -1.017	0.067 (-0.378)	-0.151 (-0.567)	1.032 (-0.430)	0.706 -1.015
Blue Silver x Sutlej 86	0.747 -0.001	-1.683 -1.45	-1.154 -0.363	1.995 (-0.300)	0.832 -3.098	1.282 -0.558
Blue Silver x Shalimar 88	-0.253 -0.167	1.51 -1.533	0.39 -0.223	-0.925 (-2.133)	0.495 (-0.473)	-2.028 -0.455
Pirsabak 91 x Sutlej 86	-3.953 (-0.333)	3.647 (-0.050)	-0.291 -0.23	2.079 -2.2	-0.537 (-0.157)	-0.26 (-1.255)
Pirsabak 91 x Shalimar 88	-0.62 -0.167	-3.077 -1.25	-0.418 (-0.627)	0.292 -1.367	-0.176 (-0.180)	-1.8 -0.488
Sutlej 86 x Shalimar 88	1.18 -0.002	1.58 (-0.717)	-0.673 (-0.560)	-0.795 (-0.933)	-0.451 (-1.777)	-1.187 -0.02

Greater magnitude of reciprocal effects for spike-length was exhibited by the cross bread of Barani-83 x Sutlej-86 and Barani-83 x Shalimar-88.

As far as spikelets/spike are concerned, the highest value of reciprocal effects were associated in Pirsabak-91 x Sutlej86, followed by Barani83 x Pirsabak91. Blue Silver x Sutlej86 had more reciprocal effects for weight of grains than all other crosses. The data indicated that Barani83 x Shalimar88 showed the highest reciprocal effects of 1.288 for grain-yield, followed by Blue-Silver x Pirsabak91. Barani-83 x Shalimar88 also exhibited better reciprocal effects for spike-length.

The relative proportion for general combining ability, specific combining ability, and reciprocal effects were calculated in terms of percentage, in order to obtain an estimate of relative importance of additive and non-additive genetic effects.

It is evident from the data given in Table-5 that greater percentage of variance for days to mature (87.70), spike-length (69.47) and grain yield plant–1 (67.83) appeared to be due to specific combining ability effects. The results suggested that all these traits on plant were under the control of non-additive (dominance and epistasis) gene-action.

The relative proportion of 'gca' effects for plant-height was greater than 'sca' and reciprocal effects, indicating the preponderance of additive mechanism of genetic system. The importance of 'sca' and 'gca' for exploitation of variation existing in different plant-characters has been discussed by several researchers. Present findings regarding involvement of non-additive (dominance-epistasis) genetic mechanism observed in most of the yield-relating characters are in agreement with Asad et al. (1992), Mishra et al. (1994), Patil et al. (1996) and Rajara and Maheshwari (1996). However, greater relative proportion of variance due to 'gca' effects provided the information about the presence of additive genetic effects for plant-height. Similar results were reported by Khan et al. (1991), Kalwar et al. (1993), Chaudhry et al. (1994) and Ajmal et al. (2000). Due to non-additive genetic mechanism governing most of the yield-relating traits, selection of the superior plants would have to be practiced with great care while handling the plant-material in segregating generations.

The Wheat variety, Shalimar-88, proved to be the best general combiner for grain-yield along with other parameters, like spike-length and weight of 100 grains. This variety showed poor combining ability for days to maturity, which indicated that it can be used as parent for evolving high-yielding genotypes with early maturity. The second best general combiner was Barani-83, for all the traits except plant-height.

The Cross of Barani-83 x Pirsabak-91 exhibited high specific combining ability for grain yield. This cross involved good x poor combiner, and such combination may yield desirable transgressive segregant and may be exploited for varietal improvement. Such type of combination may generate superior transgressive segregant, provided at least one parent is a high-yielder.

Blue-Silver x Sutlej-86 was the best specific combiner for grain-yield, weight of 100 grains and spikelets/ spike. This hybrid showed poor specific combining ability for plant-height. Blue-Silver x Pirsabak-91 was the good specific combiner for all traits, except number of spikelets/spike and days to maturity. Specific effects

Table - 5: Estimates of Relative Proportion of Variation Components for General Combining Ability, Specific Combining Ability, Reciprocals and Error (Percentage in Parenthesis) for Certain Yield-Relating Characters

Variance components	Days to maturity	Plant-height (cm)	Spike-length (cm)	Spikelets spike^{-1} (number)	100 grain weight (g)	Grain-yield plant^{-1} (g)
$Vr._g$	0.2	35.18	0.11	0.71	0.88	0.03
	3.58	67.29	7.93	8.52	11.94	0.55
$Vr._s$	4.99	8.6	0.99	3.62	3.82	3.69
	87.7	16.43	69.47	43.47	51.83	67.83
$Vr._r$	0.1	7.14	0.1	2.9	0.38	0.26
	1.7	13.66	6.88	34.87	5.16	4.78
$Vr._e$	0.59	1.36	0.22	1.09	2.29	1.46
	10.42	-2.61	15.72	13.13	31.07	26.84

observed in these crosses (poor x poor combiner) are probably due to recessive x recessive epistasis. Such crosses may not be useful in segregating generations for isolating superior genotypes.

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