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COMBINING ABILITY ANALYSIS IN DIALLEL CROSSES OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

In order to realize the combining ability of wheat, 15 hybrids were synthesised in a 6 x 6 diallel fashion excluding reciprocals and to isolate the good combiner for various yield component traits. Results on gene action and combining ability indicated that both additive and non-additive gene effects are importance in governing the expression of these yield component traits. Single seed descent method can be applied to exploit additive gene effects whereas non-additive gene effects could be valuable in hybrid wheat breeding programs. Three parents *viz.;* K-8962, Kalyansona and Sonalika were identified as most promising parents due to having good general combining ability for grain yield and some of the other important traits. Among the crosses significant and desirable sca effects in order of merit for yield and yield contributing traits were exhibited by HUW 510 x PBW 373, HUW 510 x HUW 234, Sonalika x K-8962,Sonalika x HUW 234 and Kalyansona x K-8962. Therefore, these crosses could be utilized for further selection of high yielding progenies to achieve a quantum jump in improvement of wheat crop.

INTRODUCTION

Wheat is a predominant cereal crop of the world and constitutes important source of carbohydrate and protein. It is considered as king of cereals as it provides foods to 36% of the global population contributing 20% of the food calories. At global level, India rank second largest wheat producing nation with 13.43% global wheat production after China which contributes 17.7% to the world wheat production (USDA 2012). Hybridization is the most potent technique for breaking yield barriers and evolving varieties having a built in high yield potential. The understanding of various characters and identification of superior parents are important pre-requisite for launching effective and efficient breeding programme. Selection of parents on the basis of phenotypic performance alone is not a sound procedure since phenotypically superior lines may yield poor recombination. It is therefore, essential that parents should be chosen on the basis of their genetic value. Combining ability analysis provide information on additive and non-additive variances (*i.e.* dominance and epistasis), which are important to decide the proper parents for hybridization to produce superior hybrids. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. The information regarding general combining ability (*gca*) effects of the parents is of prime importance because it helps in successful prediction of genetic potentiality which would give desirable individuals in subsequent segregating populations. However, specific combining ability is associated with interaction effects which may be due to dominance and epistatic components of variation that are non-fixable in nature thus it would be worthful for commercial exploitation as hybrids. General combining ability effects often are larger than specific combining ability effects, but enough exceptions exist to make further use of hybrids worthwhile. Thus, gene action and combining ability relation to heterosis lies in determining whether heterosis is fixable or predictable. Busch *et al.* (1974), Bailey and Comstock (1976) and Cox and Murphy (1990) claimed that in some cases, possibility of developing predominant genotype is greater if both parents have similar performance instead of one parent being inferior or superior in terms of one or more traits. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of characters. General combining ability (GCA) is attributed to additive gene effects and additive x additive epistasis and is theoretically fixable. On the other hand, specific combining ability attributable to non-additive gene action may be due to dominance or epistasis or both and is non-fixable. The parents which are genetically superior and diverse in the traits of interest are utilized for varietal development programme. The choice of parental material used in the hybridization scheme does contribute significantly for the development of a suitable genotype. In systemic breeding programme, selection of parents with desirable characteristics having good general combining ability effects for grain yield and its components, high heterosis and high estimates of specific combining ability effects are essential. These estimates will help in formulating efficient and effective breeding procedure to bring about rapid and suitable improvement in this crop. The present investigation was therefore; attempt to obtain information on the extent of combining ability for grain yield and its related traits in the selection process and greater the response to selection a diallel cross of bread wheat was employed for determination of best combiner and their crosses.

MATERIALS AND METHODS

The diallel crosses among all possible combinations excluding reciprocals involving six wheat genotypes *viz*; HUW-510, Sonalika, PBW-373, Kalyansona, K-8962 and HUW-234. The crosses were generated in *Rabi* season 2008, to study the extent of heterosis and combining ability. Evaluated 15 cosses along with their six parents were laid out in Randomized Block Design with three replications during *Rabi* 2009 at the Field Experimentation centre of the Department of Genetics and Plant Breeding, Allahabad Agricultural Institute-Deemed University, Allahabad (U.P.). The experimental site is situated at 25.87ºN latitude and 81.5ºE latitude and 98 meter above the sea level. It has a sub-tropical climate with extremes of summer and winter. During winter, frost and during summer, hot scorching winds are common features. The methodology used to maintain two seeds per hole keeping plant to plant distance of 15 cm and row to row distance of 30 cm. The recommended agronomic practices were done timely to raise good crop stand. The observations were recorded on 10 randomly selected plants in each genotype for eight characters, *viz;* plant height, tillers per plant, spike length, grains per spike, test weight, biological yield per plant, harvest index and grain yield per plant. Mean values were subjected to analysis of variance to test the significance for each character as per methodology advocated by Panse and Sukhatme (1967). The estimates of general and specific combining ability were calculated according to the method of Griffing (1956) (method-I, model-II). Estimates of combining ability were computed according to Kempthorne (1957) and average degree of dominance by Kempthorne and Curnow (1961).

RESULTS AND DISCUSSION

Analysis of variance indicated significance differences for all the characters (Table 1). Baker (1978) suggested that importance of general and specific combining ability should be assessed by estimating the component of variance and expressing them as $2\sigma^2gca/\ (2\sigma^2g+\sigma^2s)$ ratio. The magnitude of additive variance (gca) was highly significant for plant height, tillers per plant, grains per spike, 1000 seed weight, biological yield per plant and harvest index and of non-additive variance (sca) observed highly significant for all the characters. Preponderance of additive as well as non-additive gene effects as reflected in the present investigation for the expression of characters under study was similar to the findings by Desale and Mehta, 2013. High estimates of SCA variances were observed for all the traits than corresponding GCA variances, indicating the presence of repulsion phase linkage and linkage dis-equilibrium might have resulted in an over estimation of non additive component. Similar results have also been reported in wheat by Sharma and Pawar, 2000; Kamaluddin *et al.,* 2007; Kumar *et al.,* 2011. Sokol and Baker (1977) concluded that negative association between genes results in relatively larger estimates of sca variances. The ratio of gca and sca variance as less than one and degree of dominance more than one for all the traits, indicated greater role of non-additive component in the inheritance of these characters. The presence of predominantly large amount of non-additive gene action would be necessitating the maintenance of heterozygosity in the population. Breeding methods *i.e.* Biparental mating followed by one/two cycle of reciprocal

Table 1: Analysis of variance for combining ability in wheat for various quantitative characters

Source of variance	d.f.	Plant height	Spike length	Tillers per plant	Grains per spike	Test weight	Biological Yield	Harvest index	Grain yield
Parents	5	28.66**	0.77**	2.15**	20.52**	23.52**	5.92**	9.19**	1.96**
Crosses	15	39.13**	0.95**	3.30**	21.63**	14.17**	2.18**	9.25**	1.25**
Error	40	1.83	0.13	0.13	1.26	0.16	0.28	0.60	0.08
GCA variance		16.77	0.40	1.26	12.04	14.72	3.51	5.36	1.17
SCA variance		559.62	12.19	47.57	305.58	210.06	28.45	129.69	17.53
gca/sca variance		0.03	0.033	0.026	0.039	0.07	0.12	0.04	0.07

** indicate significance at 1% level of significant

Table 2: Estimates of general combining ability of six parents of wheat for various quantitative characters

Parents	Plant height	Spike length	Tillers per plant	Grains per spike	Test weight	Biological Yield	Harvest index	Grain yield
HUW 510	-2.70**	-0.25*	0.15	_0.57	0.02	0.49**	0.71**	0.02
Sonalika	0.83	0.40**	0.54**	2.59**	1.48**	0.75**	0.12	0.27**
PBW 373	-1.51**	-0.20	-0.47**	-1.15**	0.62**	-0.19	-1.54**	-0.38**
Kalyansona	-0.28	0.17	0.05	-0.31	-3.14**	0.39*	1.32**	0.51**
K 8962	1.17*	0.24*	0.49**	1.17**	1.47**	0.19	1.02**	0.36**
HUW 234	2.49**	-0.37**	-0.75**	-1.73**	-0.45**	-1.63**	-0.22	-0.78**
S.E. (g_i)	0.44	0.12	0.12	0.36	0.13	0.17	0.25	0.09
S.E. (g_i-g_j)	0.68	0.18	0.18	0.56	0.20	0.27	0.39	0.14

** indicate significance at 1% level of significant and * indicate significance at 5% level of significant.

Table 3: Estimation of specific combining ability effects in wheat for various quantitative Characters

Crosses	Plant height	Spike length	Tillers per plant	Grains per spike	Test weight	Biological Yield	Harvest index	Grain yield
HUW510 X Sonalika	3.07*	0.56	0.33	3.16	2.50**	-1.27*	-0.61	-0.73**
HUW510 X PBW 373	-9.57**	0.16	-0.32	-0.60	-017	0.96*	3.38**	1.10**
HUW510Xkalyansona	-4.98**	0.79*	0.22	3.09**	2.83	-0.04	0.57	0.02
HUW510 X K 8962	3.53**	0.78*	1.85**	3.34**	-1.79**	-0.54	0.07	0.29
HUW510X HUW 234	3.11*	0.44	2.39**	2.31*	4.57**	1.91**	5.20**	2.12**
Sonalika X PBW 373	-5.38**	0.68*	-0.27	3.57**	-3.27**	-3.26**	0.22	-1.03**
SonalikaX kalyansona	1.33	-0.23	-1.30**	-2.93**	0.23	0.10	-1.19	-0.39
Sonalika X K 8962	-1.63	1.21**	1.90**	7.32**	1.06**	1.83**	5.71**	1.99**
Sonalika X HUW 234	-8.95**	0.62	-0.56	4.82**	-2.36**	-0.88	0.96	0.60*
PBW373 X kalyansona	-4.47**	0.22	-1.06**	2.10*	8.23**	-1.43**	-0.48	0.41
PBW 373 X K 8962	-3.93**	-0.30	1.11	1.51	1.88**	0.33	-1.75*	-0.37
PBW373 X HUW 234	-8.78*	1.12**	1.45**	1.83	2.24**	0.13	-1.05	-0.18
Kalyansona X K 8962	-5.22**	0.96**	2.48**	4.15**	-04.49**	0.78	2.49**	0.93**
Kalyansona X HUW 234	-2.54*	-0.07	0.42	-0.75	-4.47**	-0.45	1.40*	0.35
K-8962 X HUW 234	-1.76	-0.33	0.22	-1.03	0.89*	-0.25	1.74*	0.18
S.E. (S_{ij})	1.80	0.32	0.32	1.00	0.38	0.48	0.69	0.26

** indicate significance at 1% level of significant and * indicate significance at 5% level of significant.

recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic improvement. Under such situation population improvement by recurrent selection and/ or heterosis breeding may be accumulate desirable genes and breaking of undesirable linkage would be more appropriate.

General combining ability effects

The information regarding general combining ability (gca) effects of the parents is of prime importance because it helps in successful prediction of genetic potentiality which would give desirable individuals in subsequent segregating populations. Estimates of gca effects (Table 2) showed that it was not possible to pick up a good general combiner for all the characters because the combining ability of the parents was not consistent for all the yield components. The general combining ability effects of the parents indicated that three parents *viz.;* K-8962, Kalyansona and Sonalika were identified as most promising parents due to having positive significant good general combining ability for grain yield, grains per spike, test weight, biological yield per plant and harvest index, indicating the presence of additive gene action or additive x additive interaction effects and shall be included in the breeding programme for accumulation of favorable alleles in a single genetic background. It suggested that these parental lines may be used in hybridization programme to have the superior recombinants for respective traits. These outcomes clearly reflected that there is scope for combining the component traits of the parents, which would ultimately improve the yield and its attributing traits of resulting genotypes.

Specific combining ability effects

Specific combining ability is associated with interaction effects which may be due to dominance and epistatic components of variation that are non-fixable in nature; thus it would be worthful for commercial exploitation of heterosis. In the present investigation, none of the crosses exhibited high specific combining ability (sca) effects for all the characters (Table 3). The crosses HUW-510 X PBW 373, HUW-510 X HUW-234, Sonalika X K 8962, Sonalika X HUW-234 and PBW 373 X HUW-234 had high SCA effects for grain yield. HUW510 X PBW 373 also exhibited significant sca effect for biological yield and harvest index. The crosses exhibited positive significant SCA effects for all the characters except given in parenthesis *namely,* HUW510 X HUW 234 (plant height and spike length), Sonalika X K 8962 (plant height) and Kalyansona X K 8962 (test weight and biological yield). Similarly, Sonalika X HUW 234 showed good SCA for only grains per spike and grain yield. The cross combinations showing high sca and involving both or at least one good general combiners, suggesting dominance type of gene action. Thus identification of specific parental combination of producing the higher transgressive effect can be of greater value for the development of high yielding of wheat varieties. Results on gene action and combining ability indicated that both general and specific combining ability effects are important. Three parents *viz.;* K-8962, Kalyansona and Sonalika were identified as most promising parents due to having good general combining ability for grain yield, grains per spike, test weight, biological yield per plant and harvest index respectively. Five cross combinations *namely,* HUW 510 x PBW 373, HUW 510 x HUW 234, Sonalika x K-8962, Sonalika x HUW 234 and Kalyansona x K-8962 could be utilized for further selection of high yielding progenies to achieve a quantum jump in wheat improvement. After subsequent selection in advanced generations, the suggested crosses may be utilized to develop the inbred comprising the higher number of grains per spike, test weight and harvest index subsequently contributed towards seed yield. The understanding of gene action of such polygenic characters is essential for formulating effective procedure for the improvement of any crop species like Indian mustard. Thus estimates of gene effects and genetic variance studied and explained in the present investigation may certainly help in understanding the genetic potential of the breeding material and their subsequent utilization in genetic enhancement of wheat.

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