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Combining Ability Analysis for Qualitative Characters in Indian Hexaploid Wheat

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Abstract

Combining ability effects were estimated in line x tester crossing programme for five characters involving four lines and three testers in Triticum durum. It revealed preponderance of non-additive gene action for protein content, sedimentation value, Pelshenke value, DBC value and Lysine content, which suggests scope for improvement of these characters through heterosis breeding and transgressive segregants for evolving high yielding superior genotypes. PBW 343, HD 2687 and UP 2338 among tester and Diamond Bird, RL 6077, Pavon 76 and Webstar among lines were evaluated as good general combiners. Among hybrids, PBW 343 x Diamond Bird, HD 2687 x Pavon 76, PBW 343 x Webstar, were the most promising ones as they had high SCA effect and GCA effects for Protein content and its component characters. An attempt of multiple crosses with the use of all the above good general combiners would lead to obtain transgressive segregants for yield in advanced generations.

Keywords: Sedimentation, genotypes, SCA, GCA and Protein content

Introduction

Among the major crops, wheat is one of the most critical for warranting human nourishment, it is the most widely crop grown globally and is the primary source of protein for the world population (Braun *et al.*, 2010). India is considered to be the second largest producer of wheat (Sharma *et al.*, 2013, Anonymous, 2014) and occupies second position after China. The geometrical increase in India's population has been a challenge for agricultural scientists. To fulfill the projected demand of the world population for food grains, it is essential that production and productivity of wheat must be increased. However, this may not be easily achieved as there is mounting evidence that genetic gains in yield have recently been much lower than what it would be required Reynolds *et al.,* (2012). Heterosis has made a significant contribution to the improvement of many crops for yield, quality and resistance to pests (Singh, 2006). Many researchers gives reviews, which revealed that both general and specific combining abilities were involved in the improvement of yield and its contributing traits in wheat (Murphy *et al*., 2008, Singh *et al.*, 2012 and Singh *et al.*, 2014).In systematic 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. The general and specific combining ability effects are very effective genetic parameters in deciding, the next phase of breeding programme. Diallel analysis also provides a unique opportunity to test a number of lines in all possible combinations.

Material and Methods

Four ovule parents (Lines) and three pollen parents (Testers) were raised in a crossing block (**Table 1**).

Table 1: Parents and F1 hybrids used in a study of heterosis, combining ability effects

Tester (pollen parents)	
T1	PBW 343
T2	UP 2338
T3	HD 2687
Lines (ovule parents)	
L1	Diamond Bird
L2	RL 6077
L3	Pavon 76
L4	Webstar
Line x Tester (crosses)	
C1	PBW 343 x Diamond Bird
C2	UP 2338 x RL 6077
C3	HD 2687 x Pavon 76
C4	PBW 343 x Webstar
C5	UP 2338 x Diamond Bird
C6	HD 2687 x RL 6077
C7	PBW 343 x Pavon 76
C8	UP 2338 x Webstar
C9	HD 2687 x Diamond Bird
C10	PBW 343 x RL 6077
C11	UP 2338 x Pavon 76
C12	HD 2687 x Webstar

The lines and testers were sown in single rows of 3 m length with the rows and plants spaced at 30cm and 10cm, respectively, were raised. Crosses were made in all possible twelve combinations. Seeds of the twelve F_1 hybrids were planted along with their parents in Randomized Block Design with five replications. The following data recorded: protein content, sedimentation value, Pelshenke value, DBC value and Lysine content. The data were analyzed according to (Griffing, 1956) as per requirement of a Line X Tester analyses.

Results and Discussion

Analysis of variance for combing ability

The analysis of variance for combining ability for the five characters is presented in **Tables 2.**

Table 2: Analysis of variance for combining ability for qualitative character

Source	Df	Mean Square				
		Protein Content	**Sedimentation value**	**Pelshenke value**	**DBC value**	**Lysine content**
Replication	5	0.2516	0.5137	3.6472	0.0016	0.0073
Treatment	30	3.2781**	8.6977**	689.2756**	0.0007**	2.6153**
Error	168	0.1697	0.3224	4.5219	0.0009	0.0019

The analyses showed that the mean squares for GCA were significant for the five qualitative characters viz., protein content, sedimentation value, Pelshenke value, DBC value and Lysine content. Mean squares due to SCA were also significant for all measurements. Mean squares due to GCA were larger than the mean squares due to SCA for characters protein content, sedimentation value, Pelshenke value, DBC value and Lysine content. Mean squares due to SCA were larger than the mean squares due to GCA for the characters Protein Content, sedimentation value and lysine Content (**Table 3**).

Table 3: Analysis of variance for combining ability for qualitative character

Source	Df	**Means Squares**				
		Protein Content	**Sedimentation value**	**Pelshenke value**	**DBC value**	**Lysine content**
Parent	4	3.9546	12.4381	681.5167	0.0127	2.2393
Crosses	11	2.5123	10.9421	670.6249	0.0084	2.0086
Parent Vs Crosses	1	5.9248	7.5310	492.8523	0.0025	1.9542

lines	3	8.6249	42.8620	3154.8621	0.0019	7.5231
Testers	2	3.5943	4.6137	305.9301	0.0011	3.5020
Lines x Testers	6	0.1054	0.6209	38.5301	0.0004	0.0823
Error	168	0.3434	0.1213	4.2194	0.0001	0.0120
GCA	:	0.0362	0.2156	10.2378	0.0001	0.0354
SCA	:	0.7621	3.5067	203.8617	0.0002	0.7618
GCA: SCA	:	0.0631	0.0764	0.0628	0.0001	0.0531

The estimation of components of variation revealed that the SCA variance was larger than the GCA variance for all ten characters. This was also evident in the GCA \ SCA ratios, which were less than unity for all the characters.

Combining ability effects for qualitative characters

The GCA and SCA effects for the different quality characters are furnished in **Tables 4 and 5,** respectively.

Table 4 ; General combining ability effects for qualitative characters

Parent	**Protein Content**	**Sedimentation value**	**Pelshenke value**	**DBC value**	**Lysine content**
Tester (pollen parents)					
L1	0.5148*	0.9618	7.2381*	0.0264	-0.5379*
L2	0.4230**	0.5019**	6.7315**	0.0115*	0.1956
L3	-0.8637	-1.9321**	-12.7568**	-0.0386**	0.8542**
L4	-0.4623**	-0.2761**	-9.8325	-0.0135**	-0.5316
Tester (pollen parents)					
T1	0.2376*	0.6381*	5.9213	0.0093**	0.6190*
T2	0.2392*	-0.1864**	-0.1238*	-0.0002	0.5132**
T3	-0.4265**	-02134	-1.9523**	-0.0012**	-0.4015**

* - significant at 0.05% ; ** - significant at 0.01 %

Table 5. Specific combining ability effects for quantitative characters

Hybrid	**Protein Content**	**Sedimentation value**	**Pelshenke value**	**DBC value**	**Lysine content**
C1	0.1332*	0.1623	3.5641**	0.0026	0.0943*
C2	-0.0717**	1.0212*	0.1864	-0.0081*	-0.0534**
C3	-0.0094*	0.2575**	-0.2489	0.0027**	0.0761**
C4	0.8621	0.1991**	0.0869**	-0.0053**	0.0453**
C5	-0.0531	-0.0084**	-0.0086*	-0.0129**	-0.0712
C6	-0.0861**	0.1634	-0.0423**	-0.0086**	-0.0841*
C7	-0.0086*	0.2671*	-4.3726**	0.0043	0.0102*
C8	-0.1378*	0.4298	-0.8614**	-0.0015**	0.0531
C9	0.2716	-0.1123**	2.3864**	-0.0082*	0.0406
C10	0.0732**	-0.2634*	-0.4821	0.0073*	-0.0045*
C11	-0.1639*	-0.0862	-0.2713*	0.0102	0.0123**
C12	-0.0761**	0.5317**	-1.8246	-0.0024	-0.0008*

* - significant at 0.05% ;   ** - significant at 0.01 %

Protein content

For this trait, two ovule parents (L1 and L2) showed significant positive GCA effects with L1 (0.5148) showing the highest. Among pollen parents, T1 and T2 had a significant positive GCA effect. Significant negative GCA effects were produced by parents L4 and T3. Cross combinations C25, C28 produced significant positive SCA effects. Twelve hybrids (C4 and C9) produced positive but non-significant SCA effects. Seven hybrids (C2, C3, C6, C7, C8, C11 and C12) produced significant negative SCA effects.

Sedimentation value

Parent L2 and T1 showed significant positive GCA effects, of which the L7 value (0.5019) was the highest significant negative GCA effects were produced by parents L3, L4 and T2. Cross combinations C2, C3, C4, C7 and C12 produced significant positive SCA effects. Three hybrids (C1, C6 and C8) produced positive but non-significant *SCA* effects. Three hybrids (C5, C9 and C10) produced significant negative SCA effects.

Pelshenke value

Parents L1 and L2 showed significant positive GCA effects, of which L1 had the highest value (7.2381). Parents L3 and L4 had significant negative GCA effects. Among the pollen parents, T2 and T3 showed a significant negative GCA effects. Cross combinations C1, C4 and C9 had significant positive SCA effects with the highest value (3.5641) being produced by cross C1. Five cross combinations (C5, C6, C7, C8 and C11) showed significant negative SCA effects while cross C7 showed a highly significant negative SCA effect of -4.3726.

DBC value

Parents L2 and T1 had significant positive GCA effects while L3, L4 and T3 had significant negative GCA effects. Crosses C3 and C10 produced significant positive SCA effects where as crosses C2, C4, C5, C6, C8 and C9 exhibited significant negative SCA effects.

Lysine content

Parents L3 had significant positive GCA effects and L1 had significant negative GCA effects. T1 and T2 produced significant positive GCA effects while T3 exhibited significant negative GCA effects. C1, C3, C4, C7 and C11 showed significant positive SCA effects while C2, C6, C10 and C12 showed significant negative SCA effects.

General and specific combining ability effects were estimated for parents and crosses, respectively. The summary of general combining ability effects of the parents revealed that none of the parent was found to be good general combiner for all the characters. These results are akin to the findings of Dhadhal and Dobariya (2006). The information regarding general combining ability 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 population. In the present investigation, it was observed that none of the parents was found as good general combiner for all the five characters under study because the combining ability of the parents was not consistent for all the yield components**.** The magnitude and direction of combining ability effects provides the guidelines for the utilization of parents in any breeding programme. It is clear from above study that some parents are good general combiners for more than one trait indicating the presence of additive gene action and additive x additive interaction effects and shall be included in the breeding programme for the accumulation of favorable alleles in a single genetic background. Therefore these parents can be used for crossing programme to have the superior recombinants for respective traits. Similar result on GCA effects were also given by Singh *et al.*,(2012), Farshadfar *et al.*, (2013), Desale and Mehta, (2013), Yao *et al.* (2014), Singh *et al.*, (2014), Khiabani *et al.*, (2015), and Kumar *et al.*, (2015).

Hybrids also showed highly significant and significant differences for all traits protein content and sedimentation value. Highly significant difference was recorded for parent vs. hybrids in protein content, sedimentation value, Pelshenke value, DBC value and Lysine content, indicating the presence of directional dominance which resulted in heterosis for these traits. Similarly, several previous studies reported significant differences among genotypes for grain yield and yield related traits in different sets of material of wheat (Menon and Sharma, 1997; Ali and Khan, 1998; Javaid *et al.*, 2001; Solomon, 2002). Therefore, it was justifiable to estimate GCA and SCA effects for those traits which showed significant differences for genotypes.

Conclusion

Considerable genetic variation exists in wheat genotypes for improving basic yield components. Both additive and non additive gene action governs expression of qualitative yield traits. Selection for parents with high GCA effects and crosses with high SCA effects would be a suitable strategy for yield improvement in wheat.

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