*Journal of Genetics, Genomics & Plant Breeding* **1(1) 21-27 (August, 2017)**

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**RESEARCH ARTICLE**

# Combining ability studies for seed yield related attributes and quality parameters in bread wheat (*Triticum aestivum* L.)

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Manuscript received: June, 5, 2017; Decision on manuscript: June, 25, 2017; Manuscript accepted: July, 10, 2017

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## Abstract

The present study was carried out during 2008–09 and 2009–10 at N.E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar to obtain information about performance of wheat genotypes, to assess the combining ability for yield, and yield contributing traits along with quality parameters of wheat. Twenty eight hybrids were synthesized in a 8 × 8 diallel fashion excluding reciprocals. The purpose of the study was to identify and select superior parents and best hybrid combinations on the basis of estimates of general and specific combining abilities. The analysis of variance revealed that the genotypes were highly significant for all the characters studied. The results revealed that non-additive genetic variance played a predominant role in the inheritance of most of the traits. The best combinations mostly involved high × low and low × low general combiners for the characters under study. On the basis of gca effects, 3 parents, UP 2754, DBW 17 and UP 2696 were found good general combiners for grain yield and quality traits. BL 3065/DBW 16, BL 3065/ UP 2754 and BL 3065/UP 2696 were the best specific crosses for grain yield and its contributing traits.

**Key words**: Bread wheat, gca and sca effects, combining ability, gene action.

## Introduction

Wheat (*Triticum aestivum* L.) is grown almost all over the world and contributes more calories and protein to the world's diet than any other food crop (Hanson *et al.*, 1982). In India it is primarily used for making chapatti, bread and biscuits and a number of other food items which are liked in Indian diet and its uses are enormous from fast food products to industry at global level. India is the second largest producer in the world. The other major wheat producing countries are China, United States of America, Russian Federation and Canada and these 5 countries together contribute more than half of the global wheat production (Singh *et al.*, 2010). In 2012-13, India produced 92.46 million tons of wheat with an average productivity of 3119 kg/ha (Anonymous, 2013). To fulfill the increasing demand of our population, wheat production and productivity must be increased. Development of wheat varieties with high yield potential combines with good quality attributes and resistance to diseases could help sustaining the future food grain demand of the country. Therefore, efforts are needed to identify good genotypes having high yield potential involving breeding methodologies. In order to achieve this target one should be aware of genetic makeup and nature of gene action involved in controlling plant responses to different environments. For the breeding programme aiming at hybridization, information about better combiner possessing desirable traits is a pre-requisite. Knowledge of the combining ability is important in selecting suitable parents for hybridization, understanding of inheritance of quantitative traits and also in identifying the promising cross combinations for further use in breeding programmes. Keeping in view, present investigation was undertaken to study the combining ability of lines for yield and yield contributing traits along with the quality parameters.

## Materials and methods

The present study was conducted at the N. E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar located in Udham Singh Nagar (Uttarakhand). The experimental material of the study consisted of eight wheat parental genotypes i.e. PBW 550, DBW 17, Raj 4105, BL 3065, UP 2754, DBW 16, UP 2696, Naphal and their 28 F1s. The F1s were made by crossing all the eight parents in half diallel fashion during *Rabi* 2008-09. These crosses were then evaluated along with the parents and check, UP 2554 during 2009-10. The experiment was laid out in a randomized block design with three replications. Each plot consisted of two rows of two meter long with a row to row distance of 23 cm. The plant to plant distance was maintained at 10 cm by dibbling the seeds manually. Eight morphological characters namely, days to 75% heading, days to maturity, plant height at maturity, number of effective tillers per plant, spike length, number of spikelets per ear, 1000 -grain weight, seed yield per plant, and four quality traits, protein content, starch content, wet gluten and zeleny value were studied. Analysis of variance was carried out according to Fisher (1918) to determine the significant differences among genotypes. Combining ability analysis in diallel scheme was carried out following the method given by Griffing’s (1956) model l method 2.

## Results and discussion

General and specific combining ability variances and effects were estimated with a view to decipher the genetic architecture of the characters under study. Combining ability describes the breeding value of parental lines to produce hybrids (Romanus *et al.*, 2008). The general combining ability has been equated with additive gene action and specific combining ability with non-additive gene action (Griffing 1956 a). The analysis of variance revealed highly significant differences among the genotypes for all the characters studied, which indicate the presence of wide diversity among the genotypes (Table 1). The estimates of general combining ability (gca) and specific combining ability (sca) variances presented in Table 2 revealed that both additive and non-additive gene effects were important for different characters. The estimated value of $\sigma 2g$ was higher than its $\sigma 2s$ for days to maturity which indicates the predominance of additive gene action as the ratio of $\sigma 2g/\sigma 2s$ was more than unity while rest of the traits showed preponderance of non-additive gene action. The value of average degree of dominance ($\sigma 2sca/\sigma 2gca$) 1/2 for days to maturity indicated partial dominance while rest of the traits showed over dominance. In the same way, preponderance of non-additive gene effects were reported by several researchers (Singh 2003, Chaman, 2005, Heidari *et al*., 2006, Kumar *et al.*, 2011, Singh *et al*., 2012 and Singh *et al*., 2012 ) for plant height, number of tillers per plant, spike length, number of spikelets per spike, test weight, protein content, zeleny value and grain yield.

Selection of suitable genotypes and their crosses in effective hybridization is a pre requisite in order to formulate a systematic breeding programme leading to rapid and sustained improvement. The magnitude and direction of combining ability effects provide the guidelines for the utilization of parents in hybridization programme. Significant gca effects have been recorded for all the characters studied (Table 3). While considering gca effects of the parents, it was found that the parent DBW 17 was observed as good general combiner for all the 12 traits while NAPHAL was also good combiners for all the characters studied except spikelet length and number of spikelet per spike. However, PBW 550, Raj 4105, BL 3065 and DBW 16 for days to 75% heading, PBW 550, Raj 4105, BL 3065 and UP 2754 for days to maturity, PBW 550, Raj 4105, BL 3065,DBW 16 and UP 2696 for plant height were found good general combiners. Good general combiner appeared genotypes PBW 550, and DBW16 for tillers per plant, Raj 4105, BL 3065, UP 2754, DBW 16 and UP 2696 for spike length, BL 3065 and UP 2754 for number of spikelet per spike, PBW 550, Raj 415, BL 3065, UP 2754 and UP 2696 for test weight. The genotypes DB17, UP 2754 and UP 2696 were identified as good combiners for yield per plant. Meanwhile the varieties Raj 4105, BL 3065, UP 2754, DBW 16 and UP 2696 were good combiners for protein content and starch content, PBW 550, Raj 4105, BL 3065, UP 2754, DBW 16 and UP 2696 for wet gluten content and zeleny value. Such variations are expected due to differences in the genotypic constitution of the parents for different characters. Hence, these parents can be employed in breeding programmes for the overall improvement. The estimates of sca presented in Table 4 reveal that the cross BL 3065/DBW 16 had the highest specific combining ability for yield per plant followed by the cross BL 3065/ UP 2754 and BL 3065/UP 2696 involved high x low general combiners. While the cross DBW16/ NAPHAL had high specific combining ability for zeleny value and both the parents involved were found to be the best general combiners for the same characters. There are chances of recovering transgressive segregants from these combinations in later generations. In the present findings, best combinations mostly involved high × low and low × low general combiners for the characters under study. There was very rare case in which high × high general combiners were involved for best combinations. The same type of result was also observed by Kumar and Maloo (2012) and Singh *et al*., (2012). Thus, it is evident that high specific combiners are not always obtained between high general combiners but may occur between low × low or high × low general combiners. This might be probably due to the presence of dominant and epistatic gene interactions.

The differences among genotypes were highly significant for all the characters studied. The degree of dominance based on the ratio of sca and gca variances indicated that both additive and non-additive gene effects were predominant for different characters studied. Thus based on gca, the varieties DBW 17, UP 2754, UP 2696, and NAPHAL could be a better choice for the improvement of yield and component traits through hybridization. The estimates of gca effect as a whole suggest that most of the traits could be improved through hybridization and selection. BL 3065/DBW 16, BL 3065/UP 2754, BL 3065 / UP 2696 and UP 2754/NAPHAL were the best specific cross for grain yield and its contributing traits. These cross may prove to be useful in future breeding programmes

**Acknowledgements**

Authors acknowledge with thanks the Director, Experiment Station, GBPUAT, Pantnagar for providing necessary facilities to carry out the present investigation and Birsa Agricultural University, Ranchi for granting study leave.

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**Table 1. Analysis of variance for different characters in bread wheat**

| Characters | MS due to replication (df=2) | MS due to treatment (df=35) | MS due to error (df=70) |
|---|---|---|---|
| Days to heading | 15.86 | 31.94** | 1.56 |
| Days to maturity | 28.03 | 24.67** | 2.13 |
| Plant height (cm) | 24.07 | 176.01** | 8.68 |
| Effective tillers per plant | 23.96 | 36.35** | 5.72 |
| Spike length (cm) | 0.12 | 8.06** | 0.33 |
| No. of spikelet per spike | 0.39 | 4.01** | 0.51 |
| Test weight (g) | 3.58 | 36.42** | 1.33 |
| Yield per plant (g) | 36.92 | 102.37** | 21.97 |
| Protein content (%) | 0.24 | 3.07** | 0.01 |
| Starch content (%) | 8.71 | 3.77** | 0.28 |
| Wet gluten content | 0.26 | 17.60** | 0.2 |
| Zeleny value | 0.27 | 99.83** | 0.16 |

**, ** significant at 5% and 1% probability level, respectively*

**Table 2. General and specific combining ability variances in bread wheat**

| Characters | $\sigma^2$gca | $\sigma^2$sca | $\sigma^2$gca/$\sigma^2$sca (ratio) | $(\sigma^2\text{sca}/\ \sigma^2\text{gca})^{1/2}$ Mean degree of dominance |
|---|---|---|---|---|
| Days to heading | 1.87 | 7.98 | 0.23 | 2.07 |
| Days to maturity | 4.49 | 2.96 | 1.52 | 0.81 |
| Plant height (cm) | 18.56 | 23.32 | 0.80 | 1.12 |
| Effective tillers per plant | 0.93 | 10.44 | 0.09 | 11.23 |
| Spike length (cm) | 0.57 | 1.81 | 0.31 | 3.18 |
| No. of spikelet per spike | 0.14 | 1.12 | 0.12 | 8.00 |
| Test weight (g) | 0.75 | 12.74 | 0.60 | 16.99 |
| Yield per plant (g) | 2.17 | 28.09 | 0.08 | 12.94 |
| Protein content (%) | 0.12 | 0.96 | 0.13 | 8.00 |
| Starch content (%) | 0.37 | 0.53 | 0.70 | 1.32 |
| Wet gluten content | 0.80 | 5.32 | 0.15 | 6.65 |
| Zeleny value | 2.76 | 34.44 | 0.80 | 3.53 |

**Table 3. GCA effects of parents for different characters in bread wheat**

| Particulars | Days to heading | Days to maturity | Plant height (cm) | Effective tillers / plant | Spike length (cm) | No. of spikelet per spike | Test weight (g) | Yield / plant (g) | Protein content (%) | Starch content (%) | Wet gluten content | Zeleny value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PBW 550 | -1.02** | -0.92** | -4.89** | 1.20** | 0.16 | -0.05 | -0.95** | -0.60 | -0.01 | 0.07 | 0.51** | -0.21** |
| DBW 17 | -0.38** | -1.69** | -5.03** | -0.86* | -0.51** | 0.36** | -0.44* | 2.55** | -0.55** | 1.19** | -1.30** | -2.21** |
| Raj 4105 | -1.58** | -0.86** | -1.79** | -0.36 | -1.37** | 0.04 | 0.76** | 0.84 | -.014** | 0.20* | -0.96** | 0.14* |
| BL 3065 | -1.08** | -0.59* | 7.52** | -0.05 | 0.91** | -0.70** | -0.43* | -0.79 | -0.27** | 0.31** | -0.65** | -2.55** |
| UP 2754 | 0.32 | 0.74** | -0.55 | 0.60 | 0.83** | 0.59** | 1.59** | 2.11* | 0.31** | -0.33** | 0.73** | 0.74** |
| DBW 16 | 1.65** | 0.21 | -1.62** | 1.01* | -0.31** | -0.21 | -0.04 | 0.79 | -0.16** | -0.19* | -0.19** | 0.29** |
| UP 2696 | -0.28 | 0.24 | 3.18** | 0.44 | 0.48** | 0.16 | 0.67** | 1.97* | 0.32** | -0.92** | 0.98** | 1.73** |
| NAPHAL | 2.38** | 2.94** | 3.17** | -1.99** | -0.18 | -0.18 | -0.98** | -1.77* | 0.50** | -0.33** | 0.88** | 2.07** |
| SE (gi)± | 0.21 | 0.25 | 0.50 | 0.41 | 0.10 | 0.12 | 0.20 | 0.80 | 0.02 | 0.09 | 0.03 | 0.07 |
| SE (gi-gj)± | 0.32 | 0.38 | 0.76 | 0.62 | 0.15 | 0.18 | 0.30 | 1.21 | 0.03 | 0.14 | 0.04 | 0.10 |

*, ** - significant at 5 and 1% respectively

**Table 4. SCA effects of crosses for different characters in bread wheat**

| Particulars | Days to heading | Days to maturity | Plant height (cm) | Effective tillers / plant | Spike length (cm) | No. of spikelet / spike | Test weight (g) | Yield / plant (g) | Protein content (%) | Starch content (%) | Wet gluten content | Zeleny value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PBW 550/ DBW 17 | 3.46** | 2.32** | -4.26* | 2.11 | 0.40 | 0.80* | -4.31** | 3.55 | 0.51** | -0.95** | 1.45** | 5.22** |
| PBW 550/ Raj 4105 | 2.32** | 1.82* | -9.10** | 5.60** | 0.59 | 0.18 | -2.34** | 3.97 | 0.98** | 0.71* | 1.34** | 3.36** |
| PBW 550/BL 3065 | 0.82 | 0.89 | 0.66 | -0.91 | -0.02 | 1.32** | -0.93 | -7.37** | -0.50** | -0.03 | -1.01** | -3.95** |
| PBW 550/ UP 2754 | -1.24 | -0.44 | 3.99* | -0.56 | 0.06 | 0.30 | 1.02 | 2.56 | -1.04** | -0.13 | -1.48** | -4.81** |
| PBW 550/ DBW 16 | 0.09 | -0.24 | 0.20 | 2.03 | 0.53 | -0.10 | -0.20 | 0.50 | -0.54** | 0.50 | -1.60** | -2.75** |
| PBW 550/ UP 2696 | 1.69* | 0.39 | 1.01 | -4.90** | -0.06 | -0.07 | 2.64** | 1.46 | 1.18** | -0.88** | 2.86** | 7.77** |
| PBW 550/ NAPHAL | -5.31** | -2.64** | -2.66 | -3.67** | 1.27** | 1.33** | -3.69** | 3.56 | -0.93** | 0.10 | -2.37** | -5.13** |
| DBW 17/ Raj 4105 | -2.31** | -0.81 | -2.07 | -0.43 | 0.57 | -0.09 | -2.26** | 4.18 | -0.18** | -0.12 | -0.77** | -3.10** |
| DBW 17/BL 3065 | -1.48* | 1.59* | -5.10** | -2.04 | 0.12 | 0.52 | -4.45** | -2.96 | 0.24** | -0.36 | -0.02 | -1.11** |
| DBW 17/ UP 2754 | -1.54* | 1.59* | 0.99 | -2.50 | -0.07 | -0.50 | 0.53 | -0.33 | -0.07 | 0.71* | 0.34** | 0.93** |
| DBW 17/ DBW 16 | 1.12 | -0.21 | -3.40* | 0.50 | -0.43 | 0.56 | -2.24** | -2.36 | -0.43** | 0.57* | -1.85** | -2.82** |
| DBW17/ UP 2696 | -0.94 | 0.09 | 3.94* | -3.73** | 0.08 | 0.33 | -3.46** | -4.55 | -1.38** | 0.83** | -3.62** | -7.26** |
| DBW 17/ NAPHAL | -4.61** | -4.61** | -3.06 | -1.11 | 1.34** | 1.07** | 8.57** | 2.02 | -1.59** | 0.14 | 1.35** | 2.97** |
| Raj 4105/ BL 3065 | 2.06** | -1.24 | 0.16 | 1.55 | -0.15 | 1.36** | -0.01 | -2.34 | -1.09** | 0.43 | -2.30** | -4.27** |
| Raj 4105/ UP 2754 | -0.68 | -0.58 | -0.65 | -2.50 | -0.60 | -0.05 | -2.48** | -2.02 | -0.47** | 0.67* | -1.50** | -1.86** |
| Raj 4105/ DBW 16 | -3.01** | -0.71 | 0.89 | 0.29 | 0.33 | 0.74 | 1.82** | 0.65 | -0.74** | 0.66* | -1.79** | -3.81** |
| Raj 4105/ UP 2696 | 1.26 | 1.26 | 2.43 | -1.84 | 0.74* | -0.02 | 0.64 | 4.90 | 0.05 | 0.39 | -0.96** | -2.01** |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Raj 4105/ NAPHAL | -2.74** | -1.78* | -4.46** | 2.39 | 0.54 | -0.35 | 6.23** | 4.87 | -0.23** | 0.17 | -0.39** | -1.58** |
| BL 3065/ UP 2754 | -0.84 | -0.51 | 5.12** | -0.11 | -0.22 | -0.08 | 6.37** | 10.57** | 0.26** | -0.70* | 0.78** | 1.83** |
| BL 3065/ DBW 16 | -0.18 | 1.02 | -3.54* | 1.88 | 0.72* | -0.72 | 3.61** | 12.04** | -0.14* | 0.35 | -0.50** | 2.55** |
| BL 3065/ UP 2696 | 0.09 | 0.66 | 0.66 | 4.85** | 0.59 | -1.68** | 0.20 | 10.18** | 1.21** | -0.89** | 3.52** | 7.65** |
| BL 3065/ NAPHAL | -2.91** | -2.04* | -0.47 | 1.48 | 1.32** | -0.78* | -0.87 | -1.32 | 0.30** | 1.83** | 0.03 | -1.36** |
| UP 2754/ DBW 16 | 0.42 | 0.69 | 0.99 | -0.77 | 1.53** | -0.33 | -4.59** | -1.48 | -0.09 | 0.79** | 0.22** | -2.54** |
| UP 2754/UP 2696 | 2.36** | 0.66 | -4.74** | 6.10** | 0.58 | 0.90* | -3.26** | -1.89 | 1.30** | -0.68* | 2.75** | 11.49** |
| UP 2754/ NAPHAL | 2.02** | -1.04 | -7.40** | 3.33* | 1.27** | 0.97* | 0.64 | 6.23* | 1.42** | -0.47 | 2.55** | 7.82** |
| DBW 16/UP 2696 | 0.36 | 0.52 | -0.13 | 7.09** | 1.08** | 0.36 | 1.68** | -2.44 | 0.50** | -0.72* | 2.17** | 2.57** |
| DBW 16/ NAPHAL | -0.31 | -2.84** | 0.60 | 1.12 | 1.97** | 1.37** | 1.12 | 3.10 | 2.02** | -1.38** | 5.47** | 13.37** |
| UP 2696/ NAPHAL | -4.04** | -1.88* | -9.46** | 0.89 | 0.55 | 1.93** | -1.83** | 1.50 | -1.26** | 0.08 | -2.90** | -5.74** |
| **SE(Sij)±** | 0.32 | 0.76 | 1.54 | 1.25 | 0.30 | 0.37 | 0.60 | 2.45 | 0.06 | 0.28 | 0.08 | 0.21 |
| **SE(Sij-Skl) ±** | 0.92 | 1.07 | 2.15 | 1.75 | 0.42 | 0.52 | 0.84 | 3.42 | 0.09 | 0.39 | 0.11 | 0.29 |

*, ** - significant at 5 and 1% respectively