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# COMBINING ABILITY OVER ENVIRONMENTS IN AESTIVUM WHEAT

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***ABSTRACT***

***The combining ability studies made over environments (sowing dates) for seven characters in aestivum wheat using 12 x 4, line x tester set revealed that both general combining ability (gca) and specific combining ability (sea) components of variance were significant for all the characters under studied, viz. grain yield per plant, spikes per plant, grains per spike, grain weight per spike, 100-grain weight, plant height and days to heading. Both gca and sca were influenced by environments. The pooled general combining ability effects obtained for various evaluated characters revealed that among the male parents, GW 366 and LOK-1 and among the female parents, VA 2010-14 and GW 438 were the best general combiners possessed high and significant gca effects for grain yield. They also recorded the significant gca effects for various traits studied. VA 2010-14 and GW 366 had high per se performance also for all the characters. Thus, it would be worthwhile to exploit these varieties/lines for development of improved varieties of aestivum wheat. Eleven out of 48 crosses showed significant positive sca effects for grain yield per plant. In the present study, five best crosses manifested high and significant sca effects for for grain yield per plant were J 2010-7 x GW 446, J 2010-35 x LOK-1, GW 11 x GW 496, VA 2010-39 x LOK 1 and VA 2009-16 x GW 366. These could be expected to throw transgressive segragants and need exploitation in breeding programmes. As both additive and non-additive gene effects played role in the inheritance of different attributes, their simultaneous exploitation through adoption of bi-parental approach in early generation mating is advocated.***

***KEY WORDS: Aestivum, combining ability, transgressive segregant, wheat***

## INTRODUCTION

Wheat is regarded as one of the most imperative crop, extensively cultivated throughout the world, with main purpose of human consumption, supporting approximately 35 per cent of the world's population and 95 per cent of wheat grown today is hexaploid (2n=6x), which is used in bread making and other bakery products (Debasis and Khurana, 2001). The protein found in wheat is called gluten which renders wheat a multipurpose crop, and is a primary protein source for world's inhabitants. It is also regarded as an important food and feed crop based upon its production, utilization, nutritive value, and adaptation (Hogg *et al.,* 2004). Based upon, area and production, wheat ranks 1$^{st}$ globally among the cereal crops. It accounts for more than 1/3$^{rd}$ of the total world's cereal crops and is main source of calories for more than 1.5 billion people in the world. Sustainable increase in production of wheat requires breeders to explore possible ways to achieve the objectives. So, the main objective of breeders is to develop wheat cultivars with high yielding ability (Ehdaie and Waines, 1989). The yield is considered to be a complex quantitative trait because knowledge of factors responsible for high yields has been rendered difficult (Singh *et al*. 2010). Selection based upon these estimates helps to improve complex associated traits related to yield (Ahmad *et al*. 2010). Breeders should try development high yielding varieties by crossing good general combiners for grain yield and transgressive segregants should be selected from subsequent hybrids genotypes. Assessment of GCA effects for grain yield and its components offers an important mean in selecting parental genotypes to develop high yielding hybrids. The combining ability studies in a single environment may not provide precise information as environmental effects play an important role and greatly influence the combining ability estimates. There are very few reports available on environmental effects on combining ability estimates and information on these aspects is extremely lacking in *aestivum* wheat. The present investigation was, therefore, undertaken to derive information on the nature of combining ability operative in the inheritance of different economic traits and detect the role of environmental components on the combining ability estimates.

## MATERIALS AND METHODS

Twelve genetically diverse lines of *aestivum* wheat *(Triticum aestivum*) originating from different agro-climatic zones of state used as females were crossed with four males (GW 496, GW 366, GW 446 and LOK-1) and thus 48 $F_1$ were obtained. The 64 entries including 16 parents and 48 $F_1$ were sown during *rabi* 2012-13 in randomized block design providing three replications in three dates of sowing, *i.e.*, 22$^{nd}$ October, 17$^{th}$ November and 5$^{th}$ December. The plant-to-plant and row-to-row spacing were 10 cm and 20 cm, respectively. Recommended cultural practices were followed uniformly to raise the normal crop. The data were collected on five randomly selected competitive plants for seven characters. The combining ability analysis using entry means was done over three dates of sowing (environments) as per the method suggested by Kempthorne, 1957.

## RESULTS AND DISCUSSION

The analysis of variance showed significant differences among parents as well as progenies in all three sowings dates for all the evaluated characters, *viz.*, grain yield per plant, spikes per plant, grains per spike, grain weight per spike, 100-grain weight, plant height, and days to heading. The analysis of variance for combining ability for the data pooled over environments revealed that mean squares due to males, females and males x females were significant for all the characters studied indicating the importance of both additive and non-additive gene effects. However, additive gene effects were predominant except for grain yield per plant and grains per spike. The results are akin to those reported by Joshi *et al*. (2003), Joshi *et al*. (204); Khaliq *et al.* (2006), Vanpariya *et al.* (2006) and Anwar *et al.* (2011).

The mean squares due to environments were highly significant for all the characters indicating sufficient diversity among environments. The mean squares due to males x environments interaction were significant for all the characters, whereas females x environments mean squares were significant for grain yield per plant, grains per spike, 100-grain weight, plant height and days to heading. This indicated that general combining ability (gca) effects of parents were influenced by environment. Further, the mean squares due to crosses x environments interaction showed that the specific combining ability (sca) effects of crosses for majority of characters were not consistent over environments except for spikes per plant. It may, therefore, be suggested that for unbiased estimates of combining ability, the studies must be carried out over a range of environments. Similar results were reported by Singh (1973) and Singh (1979).

The pooled general combining ability effects obtained for various evaluated characters (Table 1) revealed that among the male parents, GW 366 and LOK-1 and among the female parents, VA 2010-14 and GW 438 were the best general combiners possessed high and significant gca effects for grain yield. Bikram and Ahmad (2008) found best GCA for traits like effective tillers per plant, grain weight per plant and grains per spike. They also recorded the significant gca effects for various traits studied. VA 2010-14 and GW 366 had high *per se* performance also for all the characters. High gca effects mostly contribute to additive gene effects or additive x additive interaction effects and represent fixable portion of genetic variation. Thus, it would be worthwhile to exploit these varieties/lines for development of improved varieties of *aestivum* wheat. It is suggested that population involving these lines in a multiple crossing programme may be developed for isolating high yielding varieties.

Eleven out of 48 crosses showed significant positive sca effects for grain yield per plant (Table 2). Specific combining ability effects represent dominance and epistatic component of variation, which are non-fixable in nature. However, when high sca effects are observed in crosses involving either both or one good general combiner parent, they could be successfully exploited for varietal improvement. In the present study, such 5 best crosses manifested high and significant sca effects for for grain yield per plant were J 2010-7 x GW 446, J 2010-35 x LOK-1, GW 11 x GW 496, VA 2010-39 x LOK 1 and VA 2009-16 x GW 366. These could be expected to yield transgressive and stable performing segregants in the advanced generations and, thus, need exploitation in breeding programmes. These results are supported by the earlier findings (Aslam, *et al*., 2007 and Anwar *et al*., 2011).

The present study has revealed the importance of both additive and non-additive gene effects in the inheritance of the characters studied in *aestivum* wheat. Under such situations, where both additive and non-additive gene effects are important, maximum yield gain may be attainable with a system that can exploit both additive and non-additive gene effects simultaneously. As such in certain populations, bi-parental mating as well as mating of selected plants in early segregating generations could help in developing potential population having optimum levels of homozygosity and heterozygosity. Further exploitation of such populations would lead to the development of high yielding lines.

## CONCLUSION

From the discussion, it can be concluded that among the male parents, GW 366 and LOK-1 and among the female parents, VA 2010-14 and GW 438 were the best general combiners possessed high and significant gca effects for grain yield. Thus, it would be worthwhile to exploit these varieties/lines for development of improved varieties of aestivum wheat. Five best crosses manifested high and significant sca effects for for grain yield per plant were J 2010-7 x GW 446, J 2010-35 x LOK-1, GW 11 x GW 496, VA 2010-39 x LOK 1 and VA 2009-16 x GW 366. These could be expected to throw transgressive segragants and need exploitation in breeding programmes.

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**Table 1: General combining ability effects pooled over the environments**

| Variety/ Cultures | Grains Yield Per Plant | Spikes Per Plant | Grains Per Spike | Grain Weight Per Spike | 100 Grain Weight | Plant Height | Days To Heading |
|---|---|---|---|---|---|---|---|
| **Females** | | | | | | | |
| GW 438 | 1.38* | 0.20 | 3.00 | -0.10 | 0.16* | 8.32** | 3.11** |
| VA 2009-16 | 0.50 | -0.48 | 3.32** | 0.36** | -0.06 | -1.40** | -1.83** |
| VA 2010-14 | 3.30** | 0.10 | 1.24** | 0.20 | 0.82** | 12.60** | 0.74** |
| VA 2010-23 | 0.38 | 0.40 | 0.72 | -0.08 | 0.32 | 10.08** | 0.72** |
| VA 2010-32 | -3.25** | -0.80* | -0.40 | -0.20 | -0.38** | -9.42** | -2.46** |
| J 2010-5 | -0.43 | -0.62 | -0.83 | -0.04 | -0.05 | -3.14** | -2.12** |
| J 2010-7 | 0.96 | 0.52 | -0.68 | -0.04 | 0.22** | -4.20 | 2.96** |
| J 2010-35 | 1.02 | 0.74 | -0.96** | -0.04 | -0.24** | 6.74** | 3.04** |
| GW 11 | 1.02 | 0.48 | 0.22 | 0.10 | -0.47** | -7.32** | 1.98** |
| GW 173 | -0.24 | -0.20 | 0.24 | -0.10 | -0.04 | -8.24** | -1.47 |
| VA 2010-24 | -2.26** | -1.26** | 3.04 | -0.20 | -0.84 | -8.74** | -2.42 |
| VA 2010-39 | -0.96* | -0.48 | -3.17** | -0.20 | -0.22 | -12.64** | -2.24** |
| SE± | 0.52 | 0.43 | 0.40 | 0.10 | 0.08 | 0.54 | 0.15 |
| **Males** | | | | | | | |
| GW 496 | -0.18 | 0.87** | 0.32 | -0.30 | -0.08* | 9.03** | -0.68 |
| GW 366 | 2.85** | 1.02** | 0.84** | -0.10* | -0.26** | -6.05 | -0.17** |
| GW 446 | -2.01** | -1.83** | -0.63 | 0.22** | 0.38** | -3.26** | -4.40** |
| LOK-1 | 0.56* | -0.06 | -0.69 | 0.16** | 0.09* | 0.86** | 3.36** |
| SE± | 0.43 | 0.20 | 0.25 | 0.06 | 0.04 | 0.05 | 0.32 |

***, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.***

**Table 2: Estimates of specific combining ability (sca) effects pooled over environments of crosses for various characters**

| Crosses | Grain Yield / Plant | Spikes/Plant | Grains/Spike | Grain Weight / Spike | 100 Grain Weight | Plant Height | Days to Heading |
|---|---|---|---|---|---|---|---|
| 1 x 13 | 2.15 | 0.30** | 0.30* | -0.50 | -0.04 | -0.63 | 0.86* |
| 2 x 13 | -8.08** | -0.29** | 0.02 | -0.15 | 0.52** | 0.76 | 1.82** |
| 3 x 13 | -3.45* | 0.04 | 0.30* | 0.30 | 0.65** | 1.58 | -1.49** |
| 4 x 13 | 0.88 | -0.10 | 0.24 | -1.01* | 0.47** | 2.47 | 0.68* |
| 5 x 13 | 0.35 | -0.36** | -0.17 | 0.93 | 0.26** | -2.67 | -0.65 |
| 6 x 13 | 5.92** | -0.14 | 0.00 | 0.91* | -0.70** | 0.57 | 0.88** |
| 7 x 13 | 1.62 | -0.36** | 0.04 | 0.75 | -1.00** | 2.26 | -0.33 |
| 8 x 13 | -0.27 | 0.01 | -0.01 | 0.06 | 0.73** | -7.54* | -1.05** |
| 9 x 13 | 6.35** | -0.06 | 0.24 | 0.82 | 0.08 | 12.62** | -0.05 |
| 10 x 13 | 4.51** | 0.26** | -0.04 | -0.63 | -0.21** | 2.70 | 1.80** |
| 11x 13 | -3.11 | -0.06 | 0.12 | 0.10 | -0.06 | 1.28 | 0.29 |
| 12x 13 | -4.07** | 0.13 | -0.16 | 0.14 | -0.51** | 2.90 | -0.76* |
| 1 x 14 | 5.68** | 0.03 | 0.42** | -0.72 | 0.00 | -0.05 | -0.43 |
| 2 x 14 | 6.03** | -0.05 | -0.06 | -0.39 | -0.27** | -0.49 | 1.14** |
| 3 x 14 | 1.09 | 0.11 | 0.23 | -0.26 | -0.24** | -1.77 | 0.46 |
| 4 x 14 | 5.93** | 0.13 | 0.08 | 0.24 | 0.28** | 1.00 | -0.80* |
| 5 x 14 | -0.68 | -0.03 | -0.02 | -0.14 | 0.24** | -1.67 | 0.33 |
| 6 x 14 | -3.97** | -0.16 | 0.16 | 1.24** | -0.01 | 8.16** | 1.27** |
| 7 x 14 | -6.95** | 0.08 | -0.44** | 0.15 | -0.13 | 0.13 | -0.95** |
| 8 x 14 | -12.17** | -0.16 | -0.31* | -0.37 | 0.70** | -3.18 | -0.54 |
| 9 x 14 | -4.56** | 0.05 | -0.36* | 1.64** | -1.13** | -0.76 | 1.36** |
| 10 x 14 | 1.27 | 0.15 | -0.19 | -1.32** | -0.01 | -0.87 | -0.14 |
| 11 x 14 | -3.85* | -0.11 | -0.32 | 1.84** | 0.36** | 0.85 | -1.92** |
| 12 x 14 | -3.01* | 0.08 | 0.38* | -0.03 | 1.30** | -0.62 | 1.10** |
| 1x 15 | -5.35** | 0.18* | -0.21 | -1.15** | 0.22** | 2.63 | -0.81* |
| 2 x 15 | 0.52 | -0.14 | 0.24 | 0.14 | 1.02** | -6.09 | 0.47** |
| 3 x 15 | -2.36 | -0.03 | -0.09 | 0.09 | 0.21** | -2.93 | 0.28 |
| 4 x 15 | 0.69 | 0.02 | -0.13 | -0.09 | 0.49** | -0.19 | -0.55 |
| 5 x 15 | 1.81 | -0.17* | -0.01 | -1.15** | -0.61** | 2.52 | -1.66** |
| 6 x 15 | 2.22 | -0.01 | 0.40** | -0.32 | -1.09** | 1.89 | -1.14** |
| 7 x 15 | 9.10** | 0.20* | -0.03 | -1.05* | 0.18* | 1.64 | 1.02** |
| 8 x 15 | -4.12** | 0.08 | -0.15 | -0.32 | -0.33** | -8.39** | -1.40** |
| 9 x 15 | -6.43** | -0.01 | -0.07 | 0.47 | 0.02 | -0.40 | -0.53 |
| 10 x 15 | -3.58* | 0.03 | -0.45** | -0.83 | -1.43** | -5.70 | -0.41 |
| 11 x 15 | -8.80** | -0.28** | -0.33* | -0.66 | 0.38** | -1.55 | 0.12 |
| 12 x 15 | 4.53** | 0.43** | 0.16 | -0.18 | -0.44** | -2.52 | -0.80* |
| 1 x 16 | 0.93 | 0.36** | 0.02 | 0.31 | 1.07** | 1.35 | -0.01 |
| 2 x 16 | -4.21** | -0.03 | -0.08 | 0.39 | 0.21** | 5.78 | 0.83* |
| 3 x 16 | -0.18 | 0.07 | 0.20 | 0.67 | -0.77** | 2.95 | 0.72* |
| 4 x 16 | -0.34 | -0.17* | 0.10 | 0.08 | -0.41** | -1.69 | 1.01** |
| 5 x 16 | 3.23* | -0.04 | 0.06 | 0.26 | 0.19* | 0.34 | -0.32 |
| 6 x 16 | -2.31 | -0.02 | -0.02 | -0.10 | -0.97** | 0.92 | 0.29 |
| 7 x 16 | 0.35 | 0.10 | 0.25 | -0.25 | 0.01 | 4.13 | 0.40 |
| 8 x 16 | 6.63** | -0.02 | 0.05 | -0.49 | 0.00 | 7.66* | -1.14** |
| 9 x 16 | 1.01 | -0.16 | -0.05 | 1.32** | 0.61** | -2.64 | -0.60 |
| 10 x 16 | -5.87** | -0.05 | -0.29* | -0.55 | 0.15* | 1.95 | -0.75* |
| 11 x 16 | -0.66 | 0.13 | -0.04 | -0.98* | -0.37** | -0.89 | -0.51 |
| 12x 16 | 6.06** | 0.09 | 0.11 | -0.82 | -1.20** | -6.49* | -0.56 |
| S.E. ± | 1.50 | 0.09 | 0.15 | 0.43 | 0.08 | 3.15 | 0.34 |
| S.E. ($S_{ij}$- | 2.76 | 0.16 | 0.27 | 0.80 | 0.25 | 5.79 | 0.63 |
| CD @ | 5.42 | 0.32 | 0.52 | 1.56 | 0.48 | 11.35 | 1.23 |

**, ** Significant at 5 per cent and 1 per cent levels of significance, respectively.*

Where,

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1: GW 438** | **3: VA 2010-14** | **5: VA 2010-32** | **7: J 2010-7** | **9: GW 11** | **11: VA 2010-24** | **13: GW 496** | **15: GW 446** |
| **2: VA 2009-16** | **4: VA 2010-23** | **6: J 2010-5** | **8: J 2010-35** | **10: GW 173** | **12: VA 2010-39** | **14: GW 366** | **16: LOK-1** |

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