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RESEARCH PAPER



# Line × tester analysis for yield contributing morphological traits in *Triticum aestivum* under drought conditions

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**Abstract**

The present study was carried out for the development of the water stress wheat cultivars with higher grain yield by studying the genetic basis of crucial morphological traits. Nine wheat genotypes were grouped into six lines and three testers and these parents were crossed line x tester fashion. Eighteen crosses including nine parents were planted in the field in randomized complete block design with three replications. Three drought tolerant varieties Chakwal-50, Chakwal-86 and Kohistan-97 were also sown to compare the results in water stress environment. Highest negative GCA effects were observed in WN-36 for plant height (-6.17) and flag leaf area (-1.53), while for peduncle length it was noted in 8126 lines (-1.15). Highest positive GCA effects were observed in WN-32 for a number of grains per spike (5.21), grain yield per plant (2.08) and for spikelet per spike (0.33), while for 8126 and WN-10 the number of tillers per plant (0.67) and spike length (0.25) was found, respectively. The crosses 9451 × WN-25, WN-36 × 8126, WN-10 × 8126 showed highest negative SCA effects for plant height (-8.06), flag leaf area (-2.89), and peduncle length (-2.05), respectively. Moreover, the cross combinations of WN-36 × WN-25, WN-32 × WN-25 and AARI-7 × 9526 showed positive SCA effects for number of tillers per plant (1.52), spike length (0.72) and number of spikelet per spike (0.84) respectively, while the interaction of WN-35 × 8126 crosses showed highest positive SCA effects for number of grains/spike (5.69) and grain yield/plant (2.75). The parental material used in this study and cross combinations obtained from these parents may be exploited in future breeding endeavors.

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## Introduction

Wheat (*Triticum aestivum* L.) which is famously known as the king of cereals is very important food crop of the world's community. It is a promising cereal food crop with regard to production, utilization, nutritive value, storage space qualities, adaptation and transaction (Hogg *et al.,* 2004) .Wheat being stapled food is grown in every part of Pakistan. It covers the 70% of rabi and 37% of the total cropped area of the country (Akhtar *et al.,* 2010). The yield of wheat and the end-use quality is dependent upon the genotype, environment and their interaction(Randhawa *et al.,* 2002).

Development of the drought resistant wheat cultivars is a complex process when the purpose is to combine the drought tolerance with higher grain yield. Numerous yield contributing parameters such as plant height, the number of tillers per plant, days to maturity, spikelet per spike, and grains per spike and 1000-grain weight have been reported connected to water stress tolerance of wheat (Ahmad *et al.,* 2006). Due to water stress the number of nodes decreases and inter-nodal length also shorten which results in decreased height of the main stem of the wheat plant. It also causes the production of low dry matter due to a decrease in plant stem height (Day and Intalap 1970). Water stress also causes the production of desiccated grains and also results in the early maturity of the crop (Ahmad *et al.,* 2007).

Kempthorne described that line × tester analysis is a very useful approach and can be utilized very effectively (Kempthorne, 1957). Therefore, the present study was conducted to find the gene action for water stress environment related important morphological traits in present genotypes/lines so that excellent breeding strategies may be designed for developing high yielding drought tolerant genotypes.

## Material and methods

*Breeding material*

Six lines of wheat like AARI-7(2008-09), WN-10(2008-09), WN-32(2008-09), WN-35(2008-09), WN-36(2008-09) and 9451 used as female parents and three testers e.g. 8126, 9526, and WN-25 as male parents.

The crossing was performed and also some necessary preventative measures were also taken at the time of sowing to keep the genetic material free from contamination. For the production of sufficient hybrid seed, hand emasculation and pollination was done.

*Evaluation of $F_1$ hybrids in the field*

The hybrids seeds ($F_0$) obtained from crosses along with their parents were sown in the field of the experimental area during crop season of 2012-2013 according to randomized complete block design involving three replications. Each replication comprised of 18 crosses, 6 parental genotypes, and three check varieties. The plant to plant and row to row distance was 15 and 30 centimeter, respectively. At the time of sowing two seeds per hole were sown and after germination thinning was done leaving one plant at a site for good plant health and for the purpose of drought only first irrigation was applied after 25 days of sowing and on succeeding stages no water was applied.

After the crop attained maturity, five guarded plants from each row were selected and data were recorded at an appropriate time for yield related morphological traits. Some morphological traits like Plant Height (cm), number of tillers per plant, peduncle length (cm), flag leaf area ($cm^2$), spike length (cm), number of spikelet per spike, number of grains per spike and grain yield per plant (g) were recorded.

*Statistical analysis*

The data thus collected were subjected to analysis of variance technique as given by Steel *et al.* (1997), for all the characters studied to observe the significant differences among crosses and parents. Combining ability estimates were made by using line x tester analysis as outlined by (Kempthorne, 1957).

## Results and discussion

A review of Table 1 shows that female parents (lines) showed highly significant results for plant height, flag leaf area, number of tillers per plant, number of spikelet per spike, number of grains per spike, grain plant height, number of tillers per plant, flag leaf area, grain yield per spike and peduncle length showed significant results. The interaction of line x tester showed significant results for plant height, spike length, spikelet per spike but showed highly significant results for a number of grains per spike and grain yield per plant, while showed non-significant results for a number of tillers per plant, flag leaf area and peduncle length.

**Table 1.** Analysis of variance for line × tester experiment for various morphological traits in *Triticum aestivum* under drought.

| Crosses | df | Plant height (cm) | Number of tillers per plant | Spike length (cm) | Flag leaf area (cm2) | Spikelet per spike | Number of grains per spike | Grain yield per plant (g) | Peduncle Length (cm) |
|---|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 52.14 N.S | 1.12 N.S | 0.75 N.S | 4.70 N.S | 0.10 N.S | 19.46 N.S | 2.87 N.S | 2.46 N.S |
| Genotypes | 26 | 120.32** | 3.47* | 0.87* | 58.95** | 1.30** | 94** | 14.37** | 7.12** |
| Parents | 8 | 150.74** | 4.30* | 1.01* | 95.97** | 1.58** | 131.79** | 11.92** | 3.07 N.S |
| P. Vs C. | 1 | 1.024 N.S | 1.66 N.S | 0.55 N.S | 41.91 N.S | 0.37 N.S | 3.85 N.S | 43.97** | 33.54** |
| Crosses | 17 | 113.02** | 3.18 N.S | 0.82 N.S | 42.53** | 1.225** | 81.52** | 13.79** | 7.47** |
| Lines | 5 | 145.44* | 1.24 N.S | 0.28 N.S | 56.66** | 1.59* | 99.60* | 14.19* | 7.10 N.S |
| Testers | 2 | 164.19** | 6.41** | 0.58 N.S | 152.29** | 0.93 N.S | 202.55 N.S | 10.70* | 18.09** |
| L x T | 10 | 86.58* | 3.51 N.S | 1.13* | 13.52 N.S | 0.09* | 48.27** | 14.20** | 5.53 N.S |
| Error | 52 | 38.2 | 1.78 | 0.46 | 10.51 | 0.44 | 25.07 | 4.1 | 3.01 |

**Highly Significant; *Significant; N.S= Non-significant.

**Table 2.** Mean values of parents and crosses for various morphological traits in *Triticum aestivum* under drought conditions.

| Parents | Flag leaf area | Grains per spike | Grain yield/plant | Peduncle length | Plant height | Spike length | Spikelets per spike | Number of tillers per plant |
|---|---|---|---|---|---|---|---|---|
| Females | | | | | | | | |
| AARI-7 | 21.81 | 55.47 | 12.33 | 12.19 | 90.63 | 11.69 | 18.87 | 8.2 |
| WN-32 | 27.37 | 51.4 | 12.4 | 12.09 | 74.53 | 11.14 | 17.47 | 9.067 |
| WN-35 | 23.79 | 51.13 | 13.13 | 13.27 | 93.87 | 11.19 | 17.2 | 8.667 |
| WN-36 | 27.02 | 47.33 | 12.13 | 12.65 | 82.43 | 11.33 | 17.67 | 7.867 |
| WN-10 | 21.05 | 38.73 | 12.87 | 12.67 | 89.87 | 11.34 | 17.47 | 8.933 |
| 9451 | 20.23 | 49.4 | 11.73 | 13.41 | 88.9 | 10.43 | 18.2 | 7.2 |
| Males | | | | | | | | |
| 8126 | 19.49 | 45 | 8.8 | 10.36 | 73.9 | 11.29 | 18.33 | 7.533 |
| 9526 | 37.4 | 51.6 | 9.6 | 12.27 | 85.53 | 10.2 | 18.4 | 5.333 |
| WN-25 | 28.52 | 62.53 | 15.67 | 10.87 | 88.8 | 12.12 | 19.4 | 9 |
| Crosses | | | | | | | | |
| AARI-7 × 8126 | 22.08 | 48.93 | 10.33 | 10.88 | 83.4 | 11.56 | 18.07 | 8.933 |
| WN-32 × 8126 | 24.25 | 51.53 | 11.13 | 9.7 | 89.2 | 11.68 | 18.33 | 8.933 |
| WN-35 × 8126 | 22.47 | 50.6 | 11.67 | 9.42 | 80.2 | 11.96 | 19 | 8.467 |
| WN-36 × 8126 | 25 | 44 | 7.867 | 9.713 | 80 | 10.73 | 17.53 | 6.267 |
| WN-10 × 8126 | 27.14 | 48.93 | 8.467 | 6.547 | 74 | 11.98 | 18.33 | 8.667 |
| 9451 × 8126 | 19.18 | 49.2 | 9.6 | 11.78 | 86.27 | 11.51 | 18.2 | 8.8 |
| AARI-7 × 9526 | 24.73 | 43.2 | 9.533 | 12.43 | 90 | 11.97 | 19.2 | 7.467 |
| WN-32 × 9526 | 28.62 | 52.13 | 11 | 11.65 | 87.4 | 10.19 | 17.93 | 5.933 |
| WN-35 × 9526 | 27.36 | 36.73 | 5.8 | 11.13 | 90.13 | 11.09 | 17.13 | 7.4 |
| WN-36 × 9526 | 33.43 | 48.47 | 10.73 | 9.007 | 75.57 | 10.93 | 17.33 | 6.533 |
| WN-10 × 9526 | 28.53 | 52.33 | 13 | 12.03 | 91.43 | 11.67 | 18.67 | 8.733 |
| 9451 × 9526 | 27.41 | 49.47 | 11.93 | 12.25 | 86.76 | 11.47 | 17.93 | 7.133 |
| AARI-7×WN-25 | 26.62 | 49.73 | 10.87 | 12.53 | 92.5 | 10.81 | 18.47 | 6.2 |
| WN-32×WN-25 | 27.45 | 61.47 | 15.67 | 12.4 | 94.87 | 11.93 | 19.4 | 8.6 |
| WN-35×WN-25 | 25.74 | 50.27 | 11.27 | 12.31 | 92.1 | 10.72 | 19 | 7.267 |
| WN-36×WN-25 | 35.32 | 55.2 | 8.333 | 10.58 | 82.77 | 11.77 | 17.53 | 8.4 |
| WN-10×WN-25 | 27 | 55.2 | 11.33 | 10.7 | 86.93 | 11.22 | 18.33 | 7.2 |
| 9451 × WN-25 | 28.47 | 49.47 | 10.67 | 9.907 | 77.7 | 11.43 | 18.2 | 7.2 |

The male (testers) and female (lines) parents used in this study provided a broad range of expression pattern for various characters as shown in Table 2. Highest plant height was observed for WN-35(93.87 cm) while minimum plant height was shown by line 8126 (74.53 cm).

For plant height, the performance of drought tolerant variety Chakwal-86 was best (77.97 cm) because minimum plant height is desired due to the expected lodging losses. Likewise, the tester 8126 (73.90 cm) can be evaluated for future breeding programs for developing drought tolerant genotypes with reduced plant height.

Similarly, minimum flag leaf area is desirable for drought tolerance due to the reason of reduced transpiration losses from reduced area exposed to sunlight. The female parent (line) 9451 showed the minimum value (20.23 cm2) for flag leaf area, followed by WN-10 and AARI-7 which is less than the area exhibited by Chakwal-50, Chakwal-86, and Kohistan-97. WN-32 showed the maximum value (9.067 cm2) for the number of tillers per plant followed by WN-25 and WN-10 which is very close to Control varieties like Chakwal-50, Chakwal-86, and Kohistan-97. Hence, it can be concluded that for yield purpose a maximum number of tillers can be attained by WN-32 is recommended for drought tolerance with special reference to this trait.

**Table 3.** Estimates of GCA for various morphological traits in *Triticum aestivum* under drought conditions.

| Parents | Plant height (cm) | No. of tillers per plant | Spike length(cm) | Flag Leaf Area($cm^2$) | Spikelets per spike | Number of grains per spike | Grain yield per plant (g) | Peduncle length |
|---|---|---|---|---|---|---|---|---|
| AARI-7 | 3 | -0.14 | 0.08 | -0.27 | 0.32 | -2.53 | -0.3 | 1.11 |
| WN-32 | 4.86 | 0.15 | -0.1 | 2.08 | 0.33 | 5.21 | 2.08 | 0.41 |
| WN-35 | 1.85 | 0.03 | -0.11 | -0.93 | 0.12 | -3.21 | -0.9 | 0.12 |
| WN-36 | -6.17 | -0.6 | -0.22 | -1.53 | -0.78 | -0.6 | -1.5 | -0.64 |
| WN-10 | -1.5 | 0.52 | 0.25 | 0.42 | 0.18 | 2.32 | 0.42 | -1.07 |
| 9451 | -2.04 | 0.03 | 0.1 | 0.22 | -0.14 | -0.44 | 0.22 | 0.48 |
| 8126 | -3.44 | 0.67 | 0.2 | -0.66 | -0.01 | -0.95 | -0.7 | -1.15 |
| 9526 | 1.25 | -0.47 | -0.14 | -0.17 | -0.22 | -2.77 | -0.2 | 0.58 |
| WN25 | 2.18 | -0.19 | -0.05 | 0.84 | 0.23 | 3.72 | 0.84 | 0.57 |

Peduncle length was less than all other parents in 8126 (10.36 cm) whereas among drought tolerant varieties Chakwal-86 showed 7.313 cm which is highly desirable for drought tolerance. WN-25 showed the maximum spike length, the number of spikelet per spike, the number of grains per spike and grain yield per plant.

*Mean performance of the crosses*

A review of Table 2 reveals that a considerable variation in hybrid vigor is present in most of the crosses for most of the characters studied. Some hybrids/crosses even exceeded their better parents. However, some intermediate hybrids were also observed. Range in crosses for plant height was observed from 74 cm (WN-10 x 8126) to 94.867 cm (WN-32 x WN-25). Minimum value for flag leaf area was observed in the cross 9451 x 8126. The crosses AARI-7 x 8126 and WN-32 × 8126 showed the more number of tillers per plant than the drought tolerant variety Chakwal-86. So, these crosses can be further evaluated for the future breeding program. Maximum peduncle length and no. of grains per spike were recorded in the crosses AARI-7 × WN-25 and WN-32 x WN-25respectively. The cross WN-10 x 8126 displayed the maximum value for spike length, and the cross WN-32 x WN-25 had the maximum number of spikelet per spike. It was observed that the crosses showed better performance than their parents. A good degree of variation was recorded for grain yield per plant. The maximum and minimum values were obtained from the crosses WN-32 x WN-25 and WN-36 x WN-25, respectively.

*General combining ability studies*

It is clear from Table 3 that in the case of plant height, negative general combining ability effects are more important since more emphasis is placed upon selection for short stature segregate in segregating population because they ultimately turn out short stature line which is more responsive to fertilizer and tolerant to lodging. From this point of view, WN-36 and WN-10, 9451 among female parents and 8126 among male parents were potential parents and their values of general combining ability were -6.17, -1.50, -2.04 and -3.44 respectively. These results confirm the findings of (Singh *et al.,* 2003; Ivanovic, 2003). For flag leaf area, negative general combining ability effects are more important because flag leaf area is much influenced by transpiration losses due to exposure to sunlight and ultimately affects the grain yield which is our main objective.

So, more emphasis is placed on the selection of genotypes with smaller flag leaf area. From this point of view, among the female parents, AARI-7, WN-35, WN-36 and male parents 8128 and 9526 showed better performance. These findings were in accordance with the results of (Saeed *et al.,* 2001; Arshad and Chowdhry, 2002; Chowdhary *et al.,* 2007). A number of tillers per plant also plays an important role in the grain yield as more number of tillers are expected to result in better yielding ability. General combining ability effects calculated for this trait were of moderate magnitude. Among female parents, WN-10, WN-32 and male parent 8126 exhibited higher positive general combining ability effects. The findings of (Iqbal 2007; Srivastava *et al.,* 1981) supported the results reported in this write-up. Likewise in plant height, shorter peduncle length is preferred because an increase in peduncle length ultimately increases the plant height and we prefer a plant with short stature. In this study, two female parents like WN-36 and WN-10 showed the negative general combining ability. Likewise, one male parent e.g. 8126 showed superior general combining ability for this trait. So, it can be concluded that above-mentioned parents are desirable for use in the breeding program.

**Table 4.** Estimates of SCA for various morphological traits in *Triticum aestivum* under drought conditions.

| CROSSES | Plant Height (cm) | No. of Tillers/plant | spike length | Flag leaf area (cm2) | No. of spikelets/spike | No of grains/spike | Grain yield/plant (g) | Peduncle length (cm) |
|---|---|---|---|---|---|---|---|---|
| AARI-7 × 8126 | -1.78 | 0.72 | -0.09 | 0.96 | -0.5 | 2.6 | 0.75 | 0.09 |
| WN-32 × 8126 | 2.15 | 0.44 | 0.21 | 0.83 | -0.21 | -2.55 | -0.8 | -0.39 |
| WN-35 × 8126 | -3.83 | 0.08 | 0.5 | 0.63 | 0.63 | 5.69 | 2.75 | -0.37 |
| WN-36 × 8126 | 4 | -1.47 | -0.61 | -2.89 | 0.07 | -4.26 | -0.44 | 1.1 |
| WN-10 × 8126 | -6.67 | -0.2 | 0.15 | 2.94 | -0.1 | -2.26 | -1.8 | -2.05 |
| 9451 × 8126 | 6.13 | 0.41 | -0.16 | -2.48 | 0.1 | 0.78 | -0.46 | 1.62 |
| AARI-7 × 9526 | 0.1 | 0.4 | 0.67 | -1.38 | 0.84 | -1.31 | -0.53 | -0.1 |
| WN-32×9526 | -4.34 | -1.41 | -0.93 | 0.21 | -0.4 | -0.14 | -1.4 | -0.18 |
| WN-35×9526 | 1.39 | 0.16 | -0.01 | 0.53 | -1.02 | -6.36 | -3.6 | -0.41 |
| WN-36×9526 | -5.13 | -0.05 | -0.06 | 0.54 | 0.08 | 2.01 | 1.93 | -1.34 |
| WN-10×9526 | 6.05 | 1.007 | 0.19 | -0.66 | 0.44 | 2.94 | 2.24 | 1.69 |
| 9451×9526 | 1.92 | -0.13 | 0.14 | 0.75 | 0.04 | 2.85 | 1.37 | 0.35 |
| AARI-7×WN-25 | 1.67 | -1.13 | -0.58 | 0.41 | -0.34 | -1.28 | -0.22 | 0.01 |
| WN-32×WN-25 | 2.19 | 0.97 | 0.72 | -1.04 | 0.61 | 2.69 | 2.22 | 0.57 |
| WN-35×WN-25 | 2.43 | -0.24 | -0.48 | -1.17 | 0.38 | 0.67 | 0.84 | 0.78 |
| WN-36×WN-25 | 1.13 | 1.52 | 0.68 | 2.35 | -0.16 | 2.24 | -1.48 | 0.23 |
| WN-10×WN-25 | 0.62 | -0.83 | -0.35 | -2.27 | -0.34 | -0.68 | -0.44 | 0.36 |
| 9451×WN-25 | -8.06 | -0.31 | 0.01 | 1.72 | -0.14 | -3.64 | -0.91 | -1.97 |

The consequences are in line with the findings of (Sharma and Garg, 2005). Spike length is an important component since greater spike length has more number of spikelet per spike and grains per spike which ultimately results in the better grain yield potential. Therefore, increased spike length is the objective of a breeder. For this trait, parents with positive general combining ability are required. Similar studies have also been discussed by (Tosun *et al.,* 1995; Malik *et al.,* 2005; Hasnain *et al.,* 2006). Spikelet per spike contributes positively towards grain yield. More the number of spikelet per spike, greater will be the grain yield. Therefore, selection for a higher number of spikelet per spike may ultimately lead to the evaluation of better yielding lines. Among the female parents AARI-7, WN-10 and 9451 showed the positive GCA values while only one male parent 8126 was found to reveal positive general combining ability effects. These results are in the agreement with the results reported by (Tosun *et al.*, 1995; Saeed *et al.,* 2001; Malik *et al.,* 2005; Chowdhary *et al.,* 2007). A number of grains per spike are also an important factor because as the number of grains will be more, grain yield will also increase. Therefore, positive general combining ability effects are more important due to the positive contribution of grain yield. Among female parents, WN-32 and WN-10 showed positive and higher values of general combining ability effects for grains per spike while among male parents, only WN-25 showed the positive value. It should be noted that values of the female parent were higher than a male parent. These results match with the findings of (Saeed *et al.,* 2001; Singh *et al.,* 2003; Hassan *et al.,* 2007; Iqbal, 2007). For grain yield per plant, three female parents (WN-32, WN-10 and 9451) and among the male parents WN-25 exhibited positive general combining ability effects. Similar results were also found (Khan and Khan, 1999; Malik *et al.,* 2005). The highest effects were found in the female parent WN-32 followed by line WN-10.

*Specific combining ability studies*

Only six among eighteen crosses depicted negative specific combining ability effects for plant height (Table 4). If the parents with short stature are ideal one, then the crosses *viz.*, AARI-7 x 8126, WN-35 x 8126, WN-10 x 8126, WN-32 x 9526, WN-36 × 9526 and 9451 x WN-25 may be consider well. However, the remaining crosses showed higher SCA effects. These results confirmed the studies of (Arshad and Chowdhry, 2002; Ahmadi *et al.,* 2003; Hasnain *et al.,* 2006; Chowdhary *et al.,* 2007). Approximately, 45% crosses showed the smaller values of specific combining ability effects for flag leaf area which is desirable. As less flag leaf area is required for drought tolerance, the crosses WN-36 x 8126, 9451 x 8126, AARI-7 x 9526, WN-10 x 9526, WN-32 x WN-25, WN-35 x WN-25 and WN-10 x WN-25 may be used in the future breeding program because they have high SCA values contributing towards minimum flag leaf area. Similar results have also been reported by (Saeed *et al.,* 2001; Arshad and Chowdhry 2002; Nazir *et al.,* 2005; Chowdhary *et al.,* 2007). A number of tillers per plant are an important contributing trait. The crosses viz., AARI-7 x 8126, WN-32 x 8126, WN-35 x 8126, 9451 x 8126, AARI-7 x 9526, WN-35 x 9526, WN-10 x 9526, WN-32 x WN-25 and WN-36 x WN-25 exhibited the positive values for specific combining ability effects. These results are in accordance with the findings of (Hassan *et al.,* 2007). The negative specific combining ability effects are needed to reduce the peduncle length. Out of eighteen crosses, eight crosses displayed negative SCA effects. Among these, the crosses *viz.*, WN-10 x 8126, WN-36 x 9526 and 9451 x WN-25 are the best hybrids for reduced peduncle length. Similar results were reported by (Chowdhary *et al.,* 2007). In the case of spike length, positive specific combining ability effects are desired. Best crosses are those having positive and higher values of specific combining ability effects. Specific combining ability was positive in 50 % of crosses. The cross WN-32 × WN-25 showed the highest value followed by the crosses WN-36 × WN-25 and WN-35 x 8126. Similar studies have also been reported by (Hasnain *et al.,* 2006). For a number of spikelet per spike, positive specific combining ability effects were displayed in 9 crosses out of 18 crosses but AARI-1 x 9526, WN-35 x 8126 and WN-35 x WN-25 performed the best and can be recommended for the future breeding programs. Further exploration of these crosses having positive specific combining ability effects may lead to the selection of lines having more number of spikelet per spike. These results are in the conformity with those of (Singh *et al.,* 2003); (Mahantashivayogayya *et al.,* 2010). Positive specific combining ability effects were shown by 50 % of the crosses for a number of grains per spike. Potential crosses showing higher values of specific combining ability effects were WN-35 x 8126, WN-10 x 9526, 9452 x 9526, WN-32 x WN-25. The findings of (Iqbal 2007) supported the results reported in this write-up. Specific combining ability effects were found much variable among crosses for grain yield per plant. The poorest cross with respect to specific combining ability for grain yield per plant was WN-35 x 9526 whereas the cross appeared as a best and most promising specific combination was WN-35 × 8126. Positive specific combining ability effects were displayed in 07 out of 18 crosses. Such positive effects were impressive in crosses. Same results were also reported by (Saeed *et al.,* 2001; Awan *et al.,* 2005; Hassan *et al.,* 2007; Iqbal 2007; Singh *et al.,* 2007; Akbar *et al.,* 2009). Specific combining ability effects were found much variable among crosses for grain yield per plant.

The poorest cross with respect to specific combining ability for grain yield per plant was WN-32 x WN-25 whereas the cross appeared as a best and most promising specific combination was WN-35 × 9526. Positive specific combining ability effects were displayed in 10 out of 18 crosses. Such positive effects were impressive in crosses.

## Conclusion

Wheat production is mainly affected by several environmental factors and water stress is the major constraint in Pakistan. Therefore, understanding the mechanism of plant responses to water stress is an important and basic part of crops. Thus, it is need to select such genotypes of wheat which lead to better adaptation and higher yield against water stress. These studies revealed that parental genotypes like WN-10, WN-25, WN-32 and 8126 are beneficial to generate desirable combinations and may be used in future breeding strategies. Specific combinations like, WN-35 x 8126 and WN-10 x 9526 needs further investigations. Taken together, the information derived from these studies may be used to develop drought tolerant wheat material that could give economic yield in water stressed conditions of wheat growing areas.

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