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Genetic Behaviour of Wheat under Irrigated and Drought Stress Environment

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Abstract: A diallel cross involving eight bread wheat genotypes were evaluated to determine the genetic behaviour of wheat genotypes across the environments. The experimental material was planted under irrigated as well as drought stress conditions. Data collected on yield and related traits revealed highly significant differences among genotypes under both sowing conditions. Graphical analysis revealed that additive action of genes for plant height and grains per spike under irrigated conditions changed to over dominance under drought. However, it was also found that gene action for flag leaf area, 1000-grains weight and grain yield per plant remained the same over environments. It was also observed that parental genotypes shifted their positions in the graphs from recessive to dominant or the midway or vice versa, showing different genetic constitution for the same trait in response to environmental change. Genotypes displaying similar constitution under both sowing conditions showed that they contain stable genes for those particular characters and may prove useful in future breeding strategies.

Key words: Genetic behaviour, environment, drought stress, gene action, diallel, wheat

Introduction

Influence of environment on genetic architecture of the plant become evident as its phenotypic appearance. Thus, expression of plant traits depend upon the action of governing genes under prevailing environment. Alam *et al*. (1991) reported additive gene action for grains per spike and grain yield while they indicated dominant gene action for tiller number and 1000-grains weight in wheat. Lonc and Zalewski (1991) found additive gene action for plant height and 1000-grains weight and reported over dominance for tiller number, grains per spike and grain yield per plant. Prodanovic (1993) indicated the involvement of dominant gene action for tiller number, grains per spike, 1000-grains weight and grain yield. Mishra *et al*. (1996) found dominance for tiller number and over dominance for flag leaf area and grains per spike. Chowdhry *et al*. (1999) reported that additive gene action for flag leaf area under irrigated condition changed to over dominance under drought condition and over dominance for 1000-grains weight and grain yield under irrigated condition changed to partial dominance under drought, while gene action for tiller number remained partial dominant under both sowing conditions. Afiah *et al.* (2000) reported over dominance for grains per spike and 1000-grains weight. Similarly, Sheikh *et al.* (2000) observed additive gene action for plant height, grains per spike and 1000-grains weight while they observed over dominance for tiller number and grain yield.

The present study was planned to ascertain the effects of different environments on some plant traits reflecting yield potential by making a comparative assessment of their performance under irrigated and drought stress conditions, in terms of the type of gene action. This information would come in hand for putting together the necessary genetic setup of methods and materials in order to breed new wheats for drought related production situations in the country.

Materials and Methods

The studies were conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the crop season 1998-99 and 1999-2000. Eight bread wheat genotypes viz., Parula, Crow, 87094, 85205, Chakwal 97 (Chak.97), Kohistan 97 (Kohis.97), Punjab 96 (Pb.96) and MH.97 were crossed in a diallel fashion (8 × 8 full diallel) during the crop season 1998-99. For each of the cross enough female spikes were emasculated and bagged to avoid contamination with foreign pollen. Pollination with the pollen collected from the specific male parent was done when the ovaries became receptive. Seeds from each cross were harvested and saved separately.

During the next crop season (1999-2000) two experiments; one under irrigated condition and second under drought stress condition were planted on November 15, 1999. Each of the experiment was laid out in a triplicated randomized complete block design. All of the F_1s (56) along with the parents were sown in lines of 30 cm apart. All agronomic treatments i.e., hoeing, weeding, fertilization, etc. were practiced uniformly, except irrigation which was applied only to experiment sown under irrigated conditions. Data for flag leaf area, plant height, tillers per plant, grains per spike, 1000-grains weight and grain yield per plant were collected and subjected to basic analysis of variance (Steel and Torrie, 1985). Graphical analysis for gene action and determination of genetic components of variation was also conducted following Hayman (1954) and Jinks (1954).

Results and Discussion

Presence of highly significant genotypic differences for all the characters under irrigated and drought stress conditions (Table 1) allowed to proceed for further genetic analysis.

Scaling test: To test the adequacy of the data for additive-dominance model two types of scaling tests (regression analysis and analysis of variance of Wr+Vr and Wr-Vr) were employed separately for the data under irrigated and drought stress conditions (Table 2). Under irrigated condition results of the scaling tests indicated adequacy of the data for flag leaf area, plant height, 1000-grains weight and grain yield per plant. While data regarding tiller number per plant and grains per spike showed partial adequacy due to the failure of one of the two scaling tests. Under drought condition data for all the traits studied displayed complete adequacy. Thus, whole of the data under irrigated and drought stress conditions, including data showing partial adequacy were analyzed further for the determination of genetic information.

Flag leaf area: Genetic components of variation (Table 3) depicted that both D and H components were significant under both planting conditions displaying importance of additive as well as dominance effects for the control of flag leaf area. Additive effects were, however, more pronounced. Unequal values of H_1 and H_2 indicated the dissimilar distribution of positive and negative genes. Value of F was positive and significant displaying the greater frequency of dominant genes under both environments. Environmental component (E) was found non-significant under both sowing conditions.

Average degree of dominance under both sowing conditions was less than 1 (0.8 and 0.9, respectively) indicating an additive type of gene action for the control of flag leaf area. Graphical representation of the data (Fig. 1a, b) also depicted similar gene action for this trait under irrigated as well as drought stress conditions. Additive gene action for flag leaf area has also been reported by Mahmood and Chowdhry (2000). However, over dominance was reported by Mishra *et al.* (1996). Similarly, Chowdhry *et al.* (1999) reported that additive gene action for flag leaf area under irrigated condition changed to over dominance under drought stress.

Distribution of array points (Fig. 1a) indicated that the genotype 85205 contained maximum dominant genes for flag leaf area under irrigated condition closely followed by the genotypes Crow and 87094, while under drought stress conditions (Fig. 1b) maximum dominant genes for flag leaf area were present in the genotype Parula followed by the genotypes 87094 and Crow. The variety MH.97 contained the least dominant genes under both sowing conditions.

Table 1: Analysis of variance for studied traits in an 8 × 8 diallel cross of wheat

Characters		Mean squares‡ Replication	Genotypes	Error
Flag leaf area	IC	57.01**	104.77**	4.14
	DC	1.61	15.39**	1.47
Plant height	IC	44.41**	93.96**	4.67
	DC	87.22**	30.67**	5.71
Tillers per plant	IC	1.81*	2.00**	0.54
	DC	1.95**	1.59**	0.22
Grains per spike	IC	34.76*	58.35**	8.31
	DC	90.11**	40.97**	5.86
1000-grains weight	IC	9.06**	52.19**	1.22
	DC	0.09	15.72**	1.71
Grain yield per plant	IC	1.30	17.41**	1.88
	DC	0.94	3.85**	0.62

* $P \leq 0.05$, ** $P \leq 0.01$, IC = Irrigated condition, DC = Drought condition, ‡ DF for replication, genotypes and error mean squares is 2, 63 and 126, respectively.

Plant height: Estimation of genetic components of variation (Table 3) for plant height under irrigated condition revealed significant additive (D) as well as dominance (H) effects. Unequal H components indicated unequal distribution of dominant and recessive genes among the parents. Component F was negative but non-significant. Significant effect of the environment was also indicated. Average degree of dominance (0.79) indicated an additive type of gene action governing the plant height. Components of variation under drought stress condition revealed non-significant additive effects but significant dominant effects. Unequal values of H_1 and H_2 represented the dissimilar distribution of dominant and recessive genes among parents. Value of F was negative and significant. Significant influence of environment was also indicated. Average degree of dominance (6.57) indicated an over dominant type of gene action.

Graphic analysis of the data under irrigated conditions (Fig. 2a) displayed that the intercept of the regression line was positive showing an additive type of gene action with partial dominance while under drought stress condition (Fig. 2b) the intercept of the regression line was negative displaying an over dominant type of gene action. Additive gene action for plant height was also reported by Lonc and Zalewski (1993) and Sheikh *et al.* (2000). However, an over dominance gene action was reported by Afiah *et al.* (2000).

Distribution of array points under irrigated condition (Fig. 2a) depicted that the genotypes MH.97 and 85205 contained maximum dominant genes while Crow being farthest from the origin hold the least dominant genes.

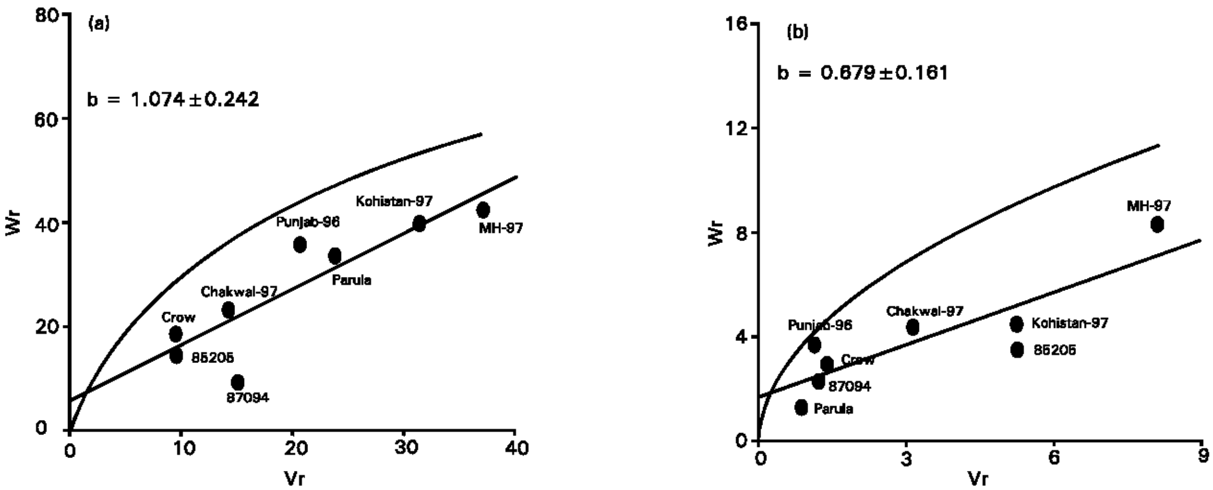

Fig. 1: Wr/Vr graph for flag leaf area under a) irrigated and b) drought stress conditions

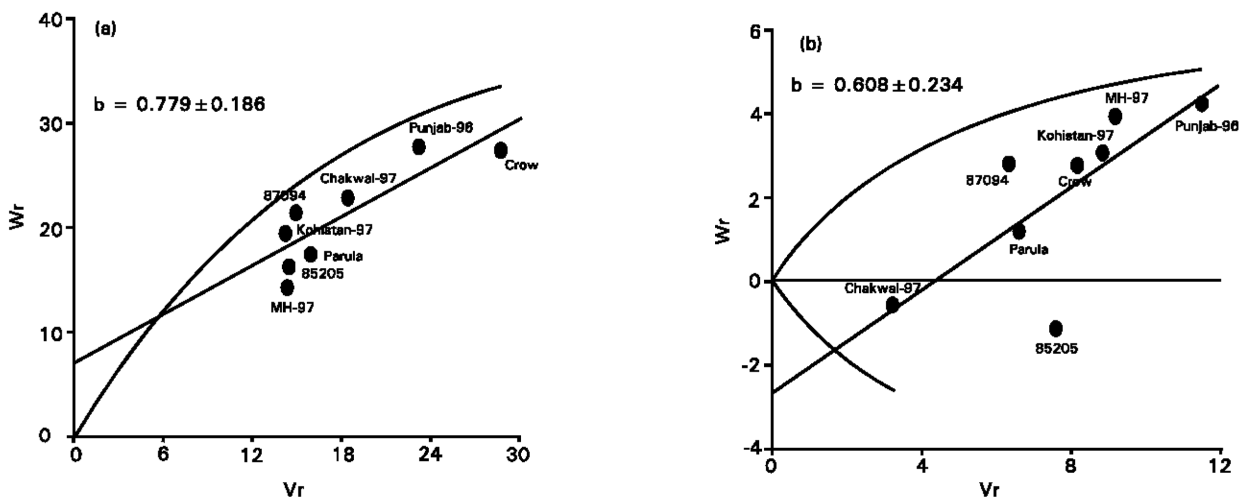

Fig. 2: Wr/Vr graph for plant height under a) irrigated and b) drought stress conditions

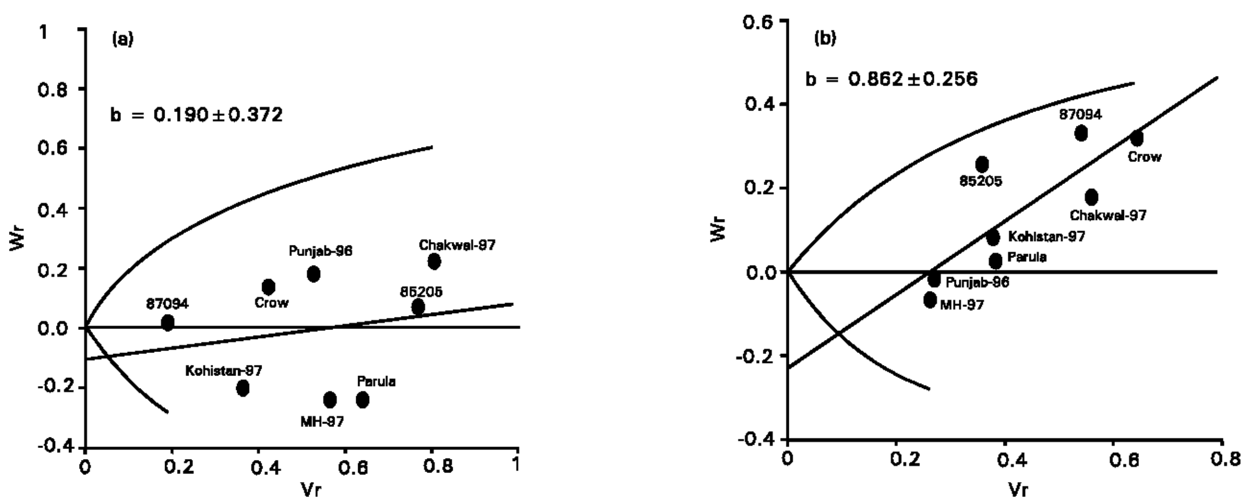

Fig. 3: Wr/Vr graph for tillers per plant under a) irrigated and b) drought stress conditions

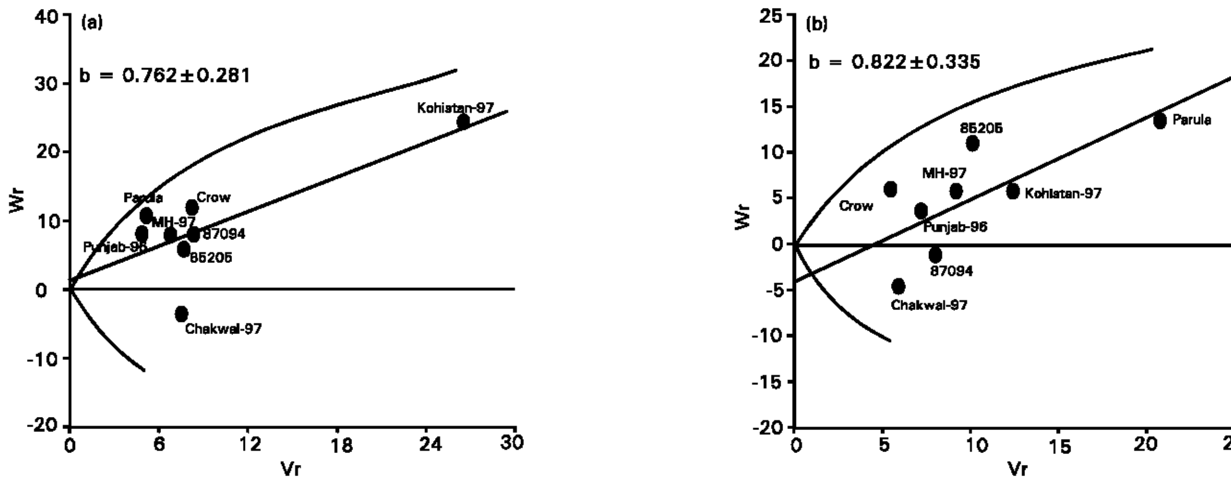

Fig. 4: Wr/Vr graph for grains per spike under a) irrigated and b) drought stress conditions

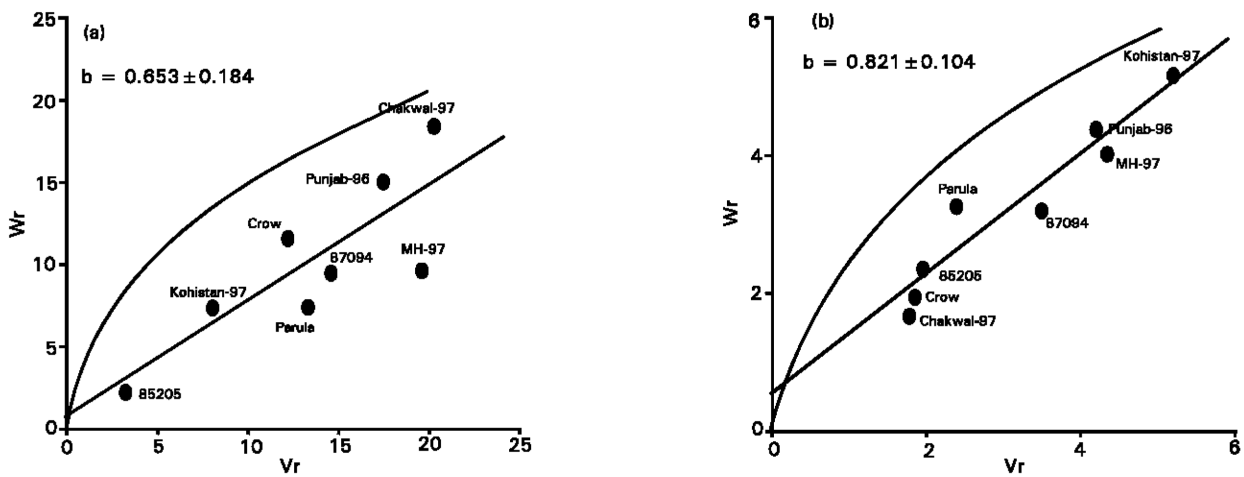

Fig. 5: Wr/Vr graph for 1000-grains weight under a) irrigated and b) drought stress conditions

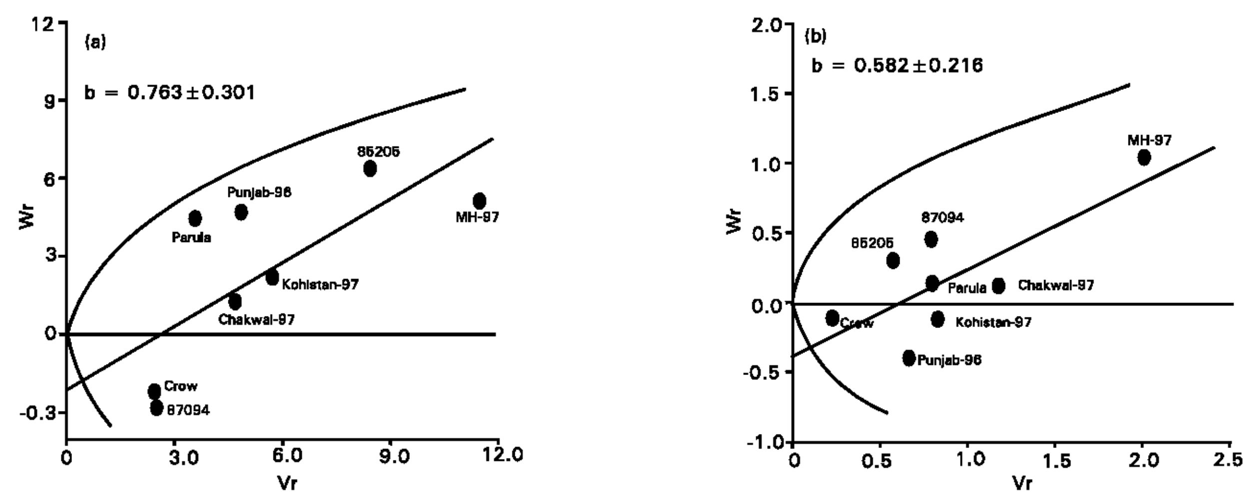

Fig. 6: Wr/Vr graph for grain yield per plant under a) irrigated and b) drought stress conditions

Table 2: Adequacy test of additive-dominance model for an 8 × 8 diallel cross of wheat

		Regression analysis		Analysis of array variances		
Plant traits	b=0	b=1		Wr+Vr	Wr-Vr	Remarks
Flag leaf area	IC	**	NS	**	NS	Both tests showed adequacy of the modal.
	DC	**	NS	NS	NS	Both tests showed adequacy of the modal.
Plant height	IC	**	NS	**	NS	Both tests showed adequacy of the modal.
	DC	*	NS	NS	NS	Both tests showed adequacy of the modal.
Tillers per plant	IC	NS	NS	NS	NS	Regression analysis invalidated the modal but analysis of arrays showed adequacy of the modal, thus, data were considered partially adequate.
	DC	*	NS	NS	NS	Both tests showed adequacy of the modal.
Grains per spike	IC	*	NS	**	**	Regression analysis indicated adequacy of the modal but analysis of arrays invalidated it, thus data were considered partially adequate.
	DC	*	NS	**	NS	Both tests showed adequacy of the modal.
1000-grains weight	IC	*	NS	**	NS	Both tests showed adequacy of the modal.
	DC	**	NS	NS	NS	Both tests showed adequacy of the modal.
Grain yield per plant	IC	*	NS	**	NS	Both tests showed adequacy of the modal.
	DC	*	NS	NS	NS	Both tests showed adequacy of the modal.

IC = Irrigated condition, DC = Drought condition * = significant at $P \leq 0.05$, ** = Significant at $P \leq 0.01$,
NS = Non-significant b = Regression coefficient Vr = Array variance Wr = Covariance of array and parental values

Under drought stress condition (Fig. 2b) the genotype Chak.97 had the greatest number of dominant genes while lowest number of dominant genes were observed in Pb.96.

Tillers per plant: Under irrigated condition dominant gene effects (significant H components) were important for number of tillers per plant. However, unequal distribution of dominant and recessive genes among parents was indicated by unequal values of H_1 and H_2. F was positive but non-significant. Average degree of dominance (2.70) also displayed an over dominance type of gene action governing the trait.

Genetic components of variation under drought stress revealed significant additive as well as dominant variation. Unequal values of H_1 and H_2 displayed asymmetry of gene distribution among the parents. F was negative but non-significant. Significant effect of environment (E) was also indicated. Average degree of dominance (2.30) indicated an over dominant type of gene action for tiller number per plant under drought.

Graphical presentation of the data (Fig. 3) also depicted an over dominant type of gene action governing tiller number per plant under both sowing conditions. The regression line cut the Wr axis below the origin in both cases. These results are in agreement with the findings of Alam *et al.* (1991), Lonc and Zalewski (1991) and Sheikh *et al.* (2000) who also reported an over dominant gene action for tiller number per plant. However, Chowdhry *et al.* (1999) reported a partial dominance for tiller number per plant under irrigated as well as drought stress conditions while Mishra *et al.* (1996) reported complete dominance for this trait. Distribution of array points displayed that under irrigated condition (Fig. 3a) genotype 87094 and Kohis.97 contained the most dominant genes for tillers number per plant while Chak.97 had the minimum number of dominant genes. In case of drought stress (Fig. 3b) MH.97 and Pb.96 were the repositories of highest dominant genes and Crow had the lowest dominant genes.

Grains per spike: Significance of additive (D) and dominance (H) variation (Table 3) for grains per spike was revealed under both sowing conditions. Unequal values of H_1 and H_2 indicated the different distribution of dominant and recessive genes among the parents. Positive and significant values of F (29.1 and 19.2) indicated the greater frequency of dominant genes under both sowing conditions. Environmental component of variation (E) remained non-significant under both planting conditions. Average degree of dominance under irrigated conditions (0.963) and the graphical analysis (Fig. 4a) displayed the presence of additive type of gene action for grains per spike.

Average degree of dominance (1.37) for grains per spike under drought stress conditions indicated an over dominant type of gene action. Similar gene action was displayed in the Wr/Vr graph (Fig. 4b) for the trait under study where the regression line cut the Wr-axis below the origin. Over dominant gene action for grains per spike has also been reported by Lonc and Zalewski (1991), Mishra *et al.* (1996) and Afiah *et al.* (2000). However, Alam *et al.* (1991) and Sheikh *et al.* (2000) found additive gene action with partial dominance for grains per spike.

Distribution of array points in the graphs indicated the dominant gene distribution in the parental genotypes. It was observed that Pb-96 contained the maximum dominant genes for grains per spike under irrigated and Chak-97 under drought stress conditions. However, Kohis.97 was the least dominant genes holder under irrigated condition and Parula was indicated as the repository of least dominant genes under drought stress condition.

Table 3: Genetic components of variation for studied traits in an 8 × 8 diallel cross of wheat

Components	Flag leaf area		Plant height		Tillers per plant		Grains per spike		1000-grains weight		Grain yield per plant	
	IC	DC	IC	DC	IC	DC	IC	DC	IC	DC	IC	DC
D	86.1*±4.5	15.5*±1.0	37.4*±2.0	0.5±1.2	0.3±0.2	0.2*±0.1	31.5*±3.9	18.8*±3.1	19.5*±2.6	5.7*±0.3	6.8*±1.9	1.0*±0.3
H_1	54.7*±10.4	12.4*±2.3	23.4*±4.6	20.1*±2.9	2.3*±0.4	1.3*±0.2	29.2*±9.0	35.6*±7.3	33.2*±5.9	4.8*±0.7	18.8*±4.3	3.6*±0.6
H_2	36.1*±9.0	7.5*±2.0	19.4*±4.0	15.6*±2.5	1.5*±0.4	1.1*±0.1	17.1*±7.9	26.9*±6.3	30.3*±5.1	4.0*±0.6	17.6*±3.7	2.7*±0.6
F	63.1*±10.7	15.6*±2.4	-8.5±4.8	-6.2*±3.0	0.7±0.4	-0.03±0.2	29.1*±9.3	19.2*±7.5	-0.5±6.0	-1.1±0.8	4.9±4.4	1.4*±0.6
E	1.2±1.5	0.4±0.3	1.3*±0.7	1.7*±0.4	0.14*±0.06	0.1*±0.02	2.2±1.3	1.8±1.1	0.3±0.9	0.4*±0.1	0.5±0.6	0.2±0.1
$\sqrt{H_1/D}$	0.80	0.90	0.79	6.57	2.70	2.30	0.96	1.37	1.30	0.91	1.66	1.94

IC = Irrigated condition, DC = drought stress condition D = Additive variation, H_1 = Variation due to dominant effect of genes, H_2 = Variation due to dominant effect of genes correlated for gene distribution,
F = Relative frequency of dominant and recessive alleles, E = Environmental variation, $\sqrt{H_1/D}$ = Average degree of dominance. * significant value

1000-grains weight: Determination of genetic components of variation for 1000-grain weight (Table 3) revealed that both additive (D) and dominant (H) variations were significant under irrigated as well as drought stress conditions. H_1 and H_2 components were unequal displaying the different distribution of dominant and recessive genes among the parents. Value of F was negative but non-significant under both sowing conditions. The effect of environment was non-significant under irrigated condition and significant under drought stress condition. Average degree of dominance (1.30) under irrigated condition (Table 3) showed an over dominant gene action. However, the Wr/Vr graph (Fig. 5a) displayed an additive gene action with partial dominance. Under drought stress the average degree of dominance (0.91) as well as the graphical analysis of the data (Fig. 5b) indicated an additive type of gene action. Additive gene action with partial dominance for 1000-grains weight was also reported by Lonc and Zalewski (1991) and Sheikh *et al.* (2000) while over dominance gene action for the trait was reported by Afiah *et al.* (2000). Chowdhry *et al.* (1999) found that over dominant gene action for 1000-grains weight under irrigated conditions changed to partial dominance under drought.

Distribution of array points (Fig. 5a) depicted that the genotype 85205 was located nearest to the origin, thus, having most dominant genes under irrigated condition while Chak.97 being farthest from the origin contained the least dominant genes. Under drought stress condition (Fig. 5b), in contrast, Chak.97 hold maximum dominant genes being closest to the origin while Kohis.97 contained the least dominant genes.

Grain yield: Data for grain yield per plant (Table 3) also revealed significant variation due to both additive and dominance gene effects under both sowing conditions. Unequal H_1 and H_2 components indicated different distribution of positive and negative genes under irrigated and drought stress conditions. Value of F was positive and non-significant under irrigated condition but significant under drought.

Average degree of dominance (1.66 and 1.94, respectively) and graphical presentation of the data (Fig. 6a, b) also depicted an over dominant gene action for grain yield per plant under both irrigated and drought stress conditions. These results are in conformity with the results of Lonc and Zalewski (1991) and Sheikh *et al.* (2000) who observed an over dominant gene action for grain yield per plant. Chowdhry *et al.* (1999), however, reported that over dominant gene action for grain yield per plant under irrigated conditions changed to partial dominance under drought while Alam *et al.* (1991) observed additive gene action with partial dominance for the said trait.

Distribution of array points (Fig. 6a, b) indicated that the genotype Crow hold maximum dominant genes while MH-97 contained the least dominant genes under both sowing conditions.

The overall results indicated the influence of environmental change on the expression of some traits and the genetic constitution of the parental genotypes. Average degree of dominance (Table 3) indicated that over dominance gene action for 1000-grains weight under irrigated conditions changed to additive gene action under drought while additive gene action for plant height and grains per spike under irrigated conditions changed to over dominance under drought. On the other hand graphical analysis revealed that additive action of genes for plant height and grains per spike under irrigated conditions changed to over dominance under drought. It was also observed that parental genotypes shifted their positions in the graphs from recessive to dominant or the midway or vice versa, showing different genetic constitution for the same trait in response to environmental change. However, it was also found that gene action for some characters remained the same over environments. Moreover genotypes displaying similar constitution under both sowing conditions showed that they contain stable genes for those particular characters and may prove useful in future breeding strategies

The importance of G × E (genotype × environment interaction) become evident which may limit the possibilities of selection for quantitative traits like plant height grains per spike, 1000-grains weight, grain yield per plant, etc. This emphasizes the need of testing the selected material over different sites and locations for stable performance.

References

Afiah, S.A.N., N.A. Mohamed and M.M. Salem, 2000. Statistical genetic parameters, heritability and graphical analysis in 8 × 8 wheat diallel crosses under saline conditions. Ann. Agric. Sci. Cairo, 45: 257-280.

Alam, K., M.A. Chowdhry and M.M. Asad, 1991. The inheritance of protein content, grain yield and its components in bread wheat (*Triticum aestivum* L. em. Thell.). Gomal Univ. J. Res., 11: 45-52.

Chowdhry, M.A., I. Rasool, I. Khaliq, T. Mahmood and M.M. Gilani, 1999. Genetics of some metric traits in spring wheat under normal and drought environments. Rachis, 18: 34-39.

Hayman, B.I., 1954. The theory and analysis of diallel crosses. Genetics, 32: 789-809.

Jinks, J.L., 1954. The analysis of continuous variation in a diallel cross of *Nicotiana rustica* L. varieties. Genetics, 39: 767-788.

Lonc, W. and D. Zalewski, 1991. Diallel analysis of quantitative characters in F_1 hybrids of winter wheat. Hodowla Roslin, Aklimatyzacja I Nasiennictwo, 35: 101-113.

Lonc, W. and D. Zalewski, 1993. Diallel analysis of quantitative traits of winter wheat F_2 hybrids. Symposium: Quantitative Genetics of Crops; Kudowa-Zdroj (Poland); 24-25 May 1993. Zeszyty Naukowe Akademii Rolniczej we Wroclawiu. Rolnictwo (Poland), 223: 265-272.

Mahmood, N. and M.A. Chowdhry, 2000. Inheritance of flag leaf in bread wheat genotypes. Wheat Information Service, 90: 7-12.

Mishra, P.C., T.B. Singh, S.M. Kurmvanshi and S.N. Soni, 1996. Gene action in diallel cross of bread wheat under late sown conditions. J. Soils and Crops, 6:128-131.

Prodanovic, S., 1993. Genetic values of F_1 wheat hybrids obtained in diallel crosses. Review of Research work at the Faculty of Agriculture, Belgrade, 38: 25-37.

Sheikh, S., I. Singh and J. Singh, 2000. Inheritance of some quantitative traits in bread wheat (*Triticum aestivum* L. em. Thell.) Ann. Agric. Res., 21: 51-54.

Steel, R.G.D. and J.H. Torrie, 1985. Principles and Procedures of Statistics. McGraw Hill Book Co., Inc., New York, USA.

Turner, N.C., 1979. Drought Resistance and Adaptation to Water Deficits in Crop Plants. Stress Physiology in Crop Plants, H. Mussell and R.C. Staples (eds.) John Wiley and Sons, New York.