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Inheritance of Yield and Some Other Morpho-physiological Plant Attributes in Bread Wheat under Irrigated and Drought Stress Conditions

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Abstract: A 6 x 6 diallel cross involving six bread wheat varieties i.e., Pak.81, LU26S, Inqlab 91, Rohtas 90, 4072 and 4943 was analysed to draw a Vr/Wr graph. Partial dominance alongwith additive type of gene action were exhibited for stomatal frequency, specific flag leaf weight, days to heading, plant height, spike length and 1000-grain weight under both environments. Over dominance was observed for leaf venation under irrigated as well as drought stress conditions. Whereas over dominance type of gene action changed into partial dominance or vice versa with the change of environment for flag leaf area, tillers per plant, grains per spike, biomass per plant and grain yield per plant. Genotype 4943 possessed maximum dominant genes for grain yield per plant, biomass per plant, grains per spike and tillers per plant under irrigated conditions and LU26S for 1000-grain weight, days to heading and flag leaf area. In case of drought stress conditions variety Inqlab 91 had maximum dominant genes for grain yield per plant, biomass per plant, grains per spike and plant height while genotype 4943 for 1000-grain weight, tillers per plant, days to heading and stomatal frequency. Dominant genes involved in the inheritance of leaf venation, flag leaf area, specific flag leaf weight, plant height, spike length, grains per spike, 1000-grain weight, biomass per plant and grain yield per plant and recessive genes accounted for the increase of days to heading and tillers per plant under both environments.

Key words: Graphical analysis, yield, morpho-physiological traits, bread wheat.

Introduction

The present study was conducted to investigate the F_1 data alongwith their parents to gain the information about genetic mechanism controlling grain yield and other morpho-physiologcal traits under irrigated and drought stress conditions. Sharma and Ahmad (1980) depicted from the graphical analysis that partial dominance was important for the inheritance of days to heading, plant height, grains per spike and 1000-grain weight whereas for tillers per plant and grain yield per plant overdominance was important. Lonts (1984) reported that plant height was controlled by dominance while the number of ears per plant, 1000-grain weight and grain yield per plant were determined by overdominance. Dominant genes for higher values of plant height, yield and 1000-grain weight were important and recessive genes for tillering capacity. Gill *et al.* (1986) studied correlation between Yr and Wr+Vr and indicated that for ear length, grain number per ear, and grain yield selection should be directed to increasing the frequency of dominant genes. Whereas Lonc (1987) exhibited that recessive genes increased ear length and grains per ear. However, Lonc (1989) determined the partial dominance for plant height, length of the main ear, number of grains per ear, 1000-grain weight and grain yield. Overdominance was noted for tillers per plant. Dominant genes accounted for increased plant height and tiller number. Similarly, additive type of gene action with partial dominance for number of kernels per spike and grain yield; over dominance for number of tillers per plant and 1000-grain weight were recorded by Alam *et al.* (1991). Chowdhry *et al.* (1992) reported that plant height and 1000-grain weight was influenced by partial dominance with additive effects while flag leaf area, number of tillers per plant, number of grains per spike and grain yield per plant were conditioned by non-additive (over dominance) type of gene action. Epistatic effect was significant for plant height. Similarly, Khan *et al.* (1992) observed the additive gene action with some degree of dominance for plant height, spike length and number of grains per spike. Srivastava and Nema (1993) also reported the partial dominance for flag leaf area and over dominance for biological yield and grain yield. Chowdhry *et al.* (1997) exhibited the additive type of gene action for plant height, spike length and grains per spike while over dominance for flag leaf area, tillers per plant, 1000-grain weight and grain yield per plant. Non-allelic interaction was present in all traits except plant height. However, Munir (1997) studied the graphical analysis and revealed that for plant height, leaf venation, grains per spike and 1000-grain weight were controlled by additive type of gene action while overdominance for flag leaf area, stomatal frequency, tillers per plant and grain yield per plant. Further breakthrough in yield level may be obtained by exploiting the genetic information for important morpho-physiological traits related this aspect.

Materials and Methods

The studies were conducted at University of Agriculture, Faisalabad during the year 1994-96. Six varieties/lines of bread wheat viz., Pak 81, LU26S, Inqlab 91, Rohtas 90, 4072 and 4943 were crossed in a diallel fashion. The thirty F_1's including reciprocals and their parents were space planted in triplicate randomized complete block design. A single row of 3.75 meter served as an experimental plot. Two seeds per hill were sown with the help of a dibble and later thinned to one seedling per site with a distance of 15 centimeters within rows and 30 centimeters between rows.

For two sets of experiments, one under regular irrigation and the other under non-irrigation (drought stress), the field were irrigated for seed bed preparation. After planting of experimental population, four canal irrigations were applied to normal experiment during the active growing period. Whereas the other experiment entirely depends on natural precipitation and no surface irrigation was applied to drought experiment for maintaining moisture stress conditions. Normal agronomic practices like fertilizer application and weed control were applied to both experiments.

Measurements were made on only competitive plants under both environments for morpho-physiological traits like stomatal frequency, leaf venation, flag leaf area (cm^2), specific flag leaf weight (mg/cm^2), days to heading, tillers per plant, plant height (cm), spike length (cm), grains per spike, 1000-grain weight (g), biomass pre plant (g) and grains yield per plant (g).

The data were subjected to analysis of variance for all the characters for individual environments (irrigated and drought stress conditions) according to the method of Steel and Torrie (1980). The diallel cross method developed by Hayman (1954) and applied by Mather and Jinks (1982) was used for genetic analysis of the data.

Results and Discussion

Stomatal frequency: Highly significant differences among the genotypes permitted further analysis. A graphical representation (Fig. 1a) of the results indicated that variety Rohtas 90, possessed maximum dominant genes among the genotypes studied followed by variety LU26S and genotype 4943. The maximum recessive genes for stomatal frequency were exhibited by genotype 4072 followed by variety Pak. 81. The regression line intercepted the Wr axis above the point of origin showing a partial dominance type of gene action along with an effective additive control for stomatal frequency under irrigated conditions. In case of drought stress conditions graph (Fig. 1b) disclosed that maximum dominant genes were present in genotype 4943, followed by Pak.81. The maximum recessive genes for this trait were found in genotype 4072 followed by variety LU26S and Inqlab 91. The regression line cut the Wr-axis above the point of origin indicating partial dominance type of gene action for this trait under drought stress conditions. But Munir (1997) reported the overdominance type of gene action for stomatal frequency.

Leaf venation: A graphic presentation (Fig. 2a) disclosed that maximum dominant genes for leaf venation were present in genotype 4072, followed by Inqlab 91. The maximum recessive genes for this trait were found in LU26S. The regression line cut the Wr axis below the point of origin indicating over dominance type of gene action for leaf venation under irrigated conditions.

As depicted in Figure 2b, maximum dominant genes were possessed by variety Pak.81 for leaf venation under drought stress conditions. The parent having most recessive genes was genotype 4943 followed by variety LU26S. The regression line draw between Vr and Wr cut the Wr-axis below the point of origin showing an over dominance type of gene action. In contrast to the present results Munir (1997) observed the additive type of gene action with partial dominance.

Flag leaf area: As apparent from the Figure 3a, LU26S possessed maximum dominant genes for flag leaf area under irrigated conditions followed by Pak.81. Maximum recessive genes were exhibited by Rohtas 90 followed by the genotype 4943. The regression line intercepted the Wr axis below the point of origin thus showing over dominance type of gene action. The graphical representation of Vr/Wr values (Fig. 3b) demonstrated that LU26S had maximum dominant genes for flag leaf area under drought stress conditions. The maximum recessive genes were exhibited by Rohtas 90 followed by Inqlab 91. The regression line cut the Wr axis above the point of origin showing partial dominance type of gene action and also additive type of gene action. In case of flag leaf area over dominance type of gene action was found under irrigated conditions (Chowdhry *et al.*, 1992 & 1997 and Munir, 1997), whereas Srivastava and Nema (1993) reported partial dominance for this trait, as was observed in the present study under drought stress conditions.

Specific flag leaf weight: A graphical representation (Fig. 4a) of the results indicated that Inqlab 91 by virtue of its position on regression line, possessed maximum dominant genes among the parents followed by LU26S under irrigated conditions. The maximum recessive genes were exhibited by Rohtas 90 followed by Pak.81. The regression line intercepted the Wr axis above the point of origin showing the presence of partial dominance alongwith additive genetic control. Figure 4b disclosed that maximum dominant genes for the control of this trait under drought stress conditions were present in Pak.81 followed by LU26S. The maximum recessive genes for this traits were found in genotype 4943. The regression line intercepted the Wr axis above the point of origin. This showed the partial dominance alongwith additive genetic control under drought stress conditions. From the foregoing results the presence of partial dominance type of gene action was obvious for specific flag leaf weight under both environments.

Days to heading: The graphical representation (Fig. 5a) indicated that the cultivar LU26S had maximum dominant genes for this trait under irrigated conditions. The maximum recessive genes were exhibited by the genotype 4072, followed by Pak.81. The regression line cut the Wr axis above the point of origin, showing partial dominance type of gene action alongwith additive genes. The Fig. 5b revealed that maximum dominant genes were possessed by the genotype 4043, followed by Inqlab 91 under drought stress conditions. The parent having most recessive genes turned out to be genotype 4072, followed by Pak.81. The Vr/Wr regression line cut the Wr axis above the point of origin showing partial dominance along with additive type of gene action. Sharma and Ahmad (1980) also reported similar results.

Tillers per plant: The graphical presentation (Fig. 6a) showed that maximum dominant genes were possessed by the 4943 and it was followed by Rohtas 90 under irrigated conditions. The parents having most recessive genes were Pak.81 and Inqlab 91. The regression line intercepted the Wr axis above the point of origin, indicating the presence of partial dominance along with additive type of gene action. Under drought stress conditions, the Vr/Wr graph (Fig. 6b) showed that maximum dominant genes were possessed by parent 4943 followed by Pak.81. The parents having most

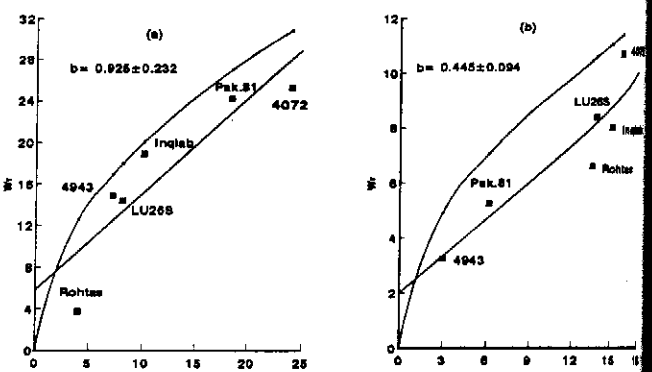

Fig. 1: Vr/Wr graph a) irrigated and b) drought stress conditions, for stomatal frequency

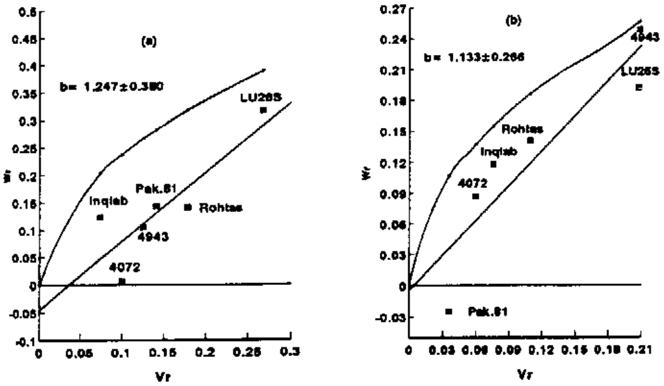

Fig. 2: Vr/Wr graph a) irrigated and b) drought stress conditions, for leaf venation

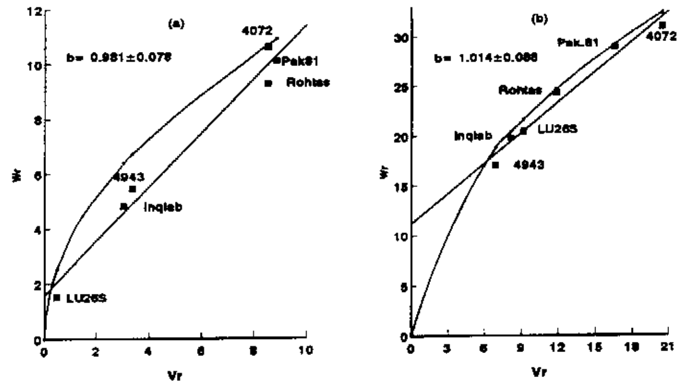

Fig. 5: Vr/Wr graph a) irrigated and b) drought stress conditions, for days to heading.

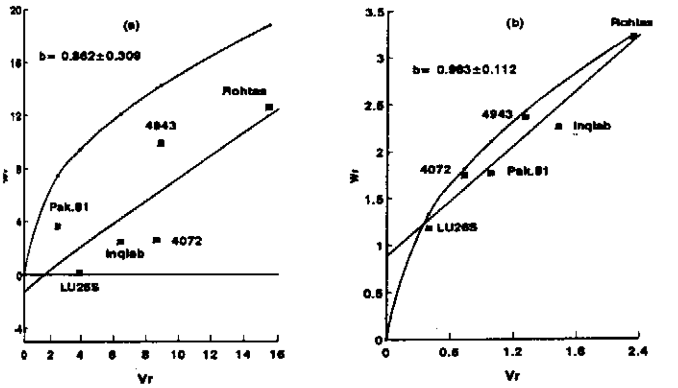

Fig. 3: Vr/Wr graph a) irrigated and b) drought stress conditions, for flag leaf area

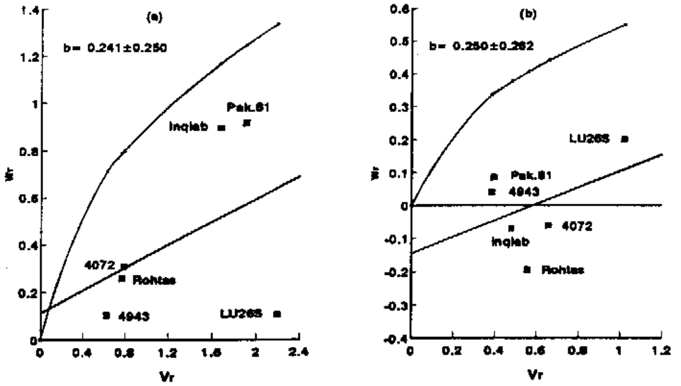

Fig. 6: Vr/Wr graph a) irrigated and b) drought stress conditions, for tillers per plant

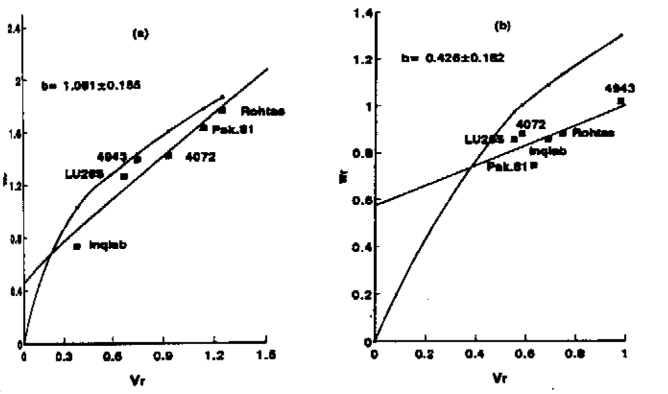

Fig. 4: Vr/Wr graph a) irrigated and b) drought stress conditions, for specific flag leaf weight

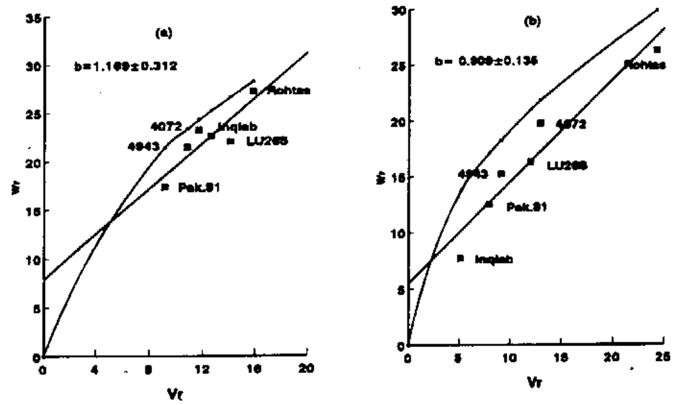

Fig. 7: Vr/Wr graph a) irrigated and b) drought stress conditions, for plant height

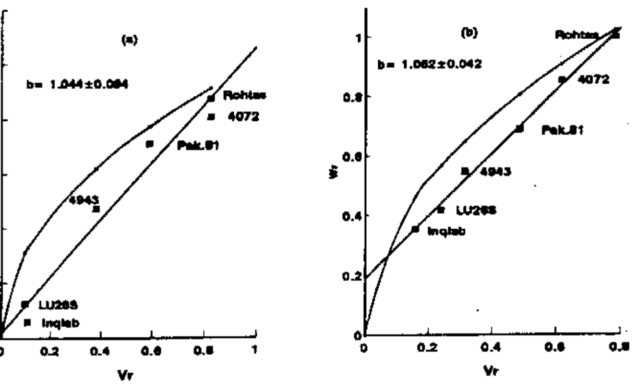

Fig. 8: Vr/Wr graph a) irrigated and b) drought stress conditions, for spike length

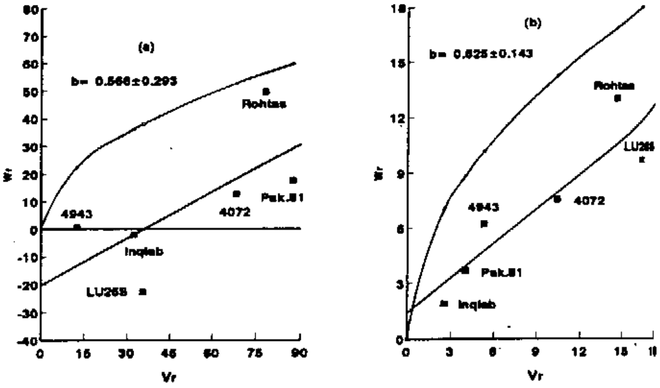

Fig. 11: Vr/Wr graph a) irrigated and b) drought stress conditions, for biomass per plant.

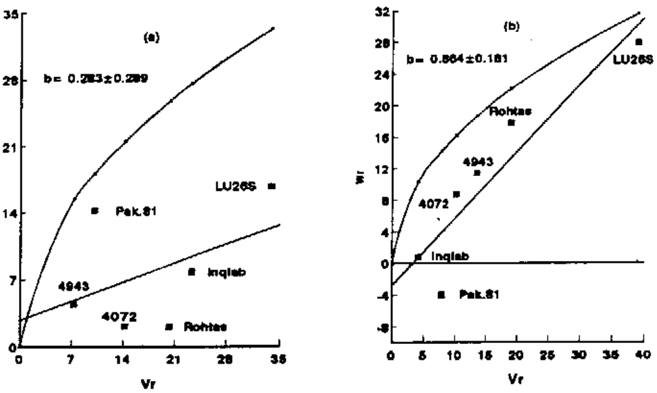

Fig. 9: Vr/Wr graph a) irrigated and b) drought stress conditions, for grains per spike

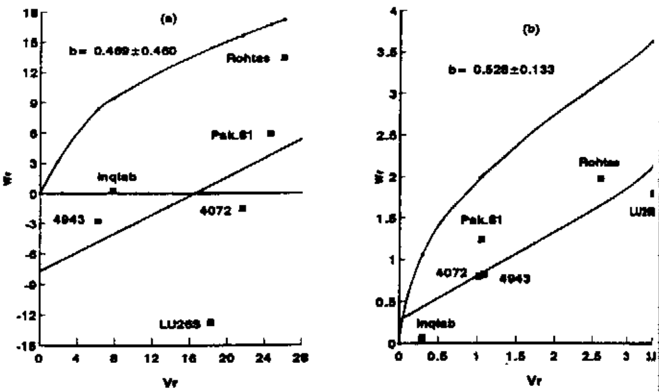

Fig. 12: Vr/Wr graph a) irrigated and b) drought stress conditions, for grain yield per plant

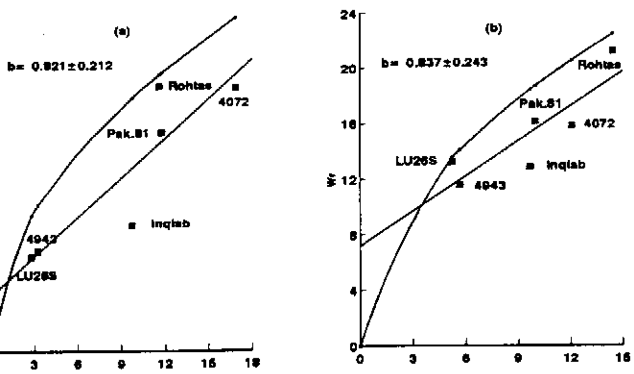

Fig. 10: Vr/Wr graph a) irrigated and b) drought stress conditions, for 1000- grain weight

recessive genes were LU26S and 4072, respectively. The regression line intercepted the Wr axis below the point of origin indicating an over dominance type of gene action. Over dominance type of gene action observed for this trait under drought stress conditions find support from the findings of Sharma and Ahmad (1980), Lonts (1984), Lonc (1989), Alam *et al.* (1991), Chowdhry *et al.* (1992 & 1997) and Munir (1997) who also reported over dominance type of gene action for tillers per plant.

Plant height: The graphical representation (Fig. 7a) disclosed that the variety Pak.81 had maximum dominant genes followed by genotype 4943 under irrigated conditions. Maximum recessive genes possessed by variety Rohtas 90. The regression line intercepted the Wr axis above the point of origin, showing a partial dominance type of gene action interlaced with an additive type of gene action. The graph (Fig. 7b) indicated that the Inqlab 91 had maximum dominant genes followed by LU26S under drought stress conditions. The maximum recessive genes were exhibited by the variety Rohtas 90 followed by 4072. The regression line cut the Wr axis above the point of origin showing a partial dominance type of gene action for this trait. These results confirmed by the findings of Sharma and Ahmad (1980), Lonc (1989), Cowdhry *et al.* (1992), Khan *et al.* (1992) and Chowdhry *et al.* (1997) Munir (1997) who also reported partial dominance for plant height. But Lonts (1984) reported the presence of dominance for this trait.

Spike length: The Vr/Wr graph (Fig. 8 a&b) showed that cultivar Inqlab 91 possessed maximum dominant genes for spike length under irrigated and drought stress conditions followed by LU26S. The maximum recessive genes were exhibited by Rohtas 90, followed by the genotype 4072. The regression line intercepted the Wr axis above the point of origin, showing partial dominance involved in the spike length under irrigated and drought stress conditions. For spike length, partial dominance was found under both environments. These findings are supported by the results of Lonc (1989), Khan *et al.* (1992) and Chowdhry *et al.* (1997).

Grains per spike: The graphical representation (Fig. 9a) indicated that cultivar 4943 being closest to the origin had maximum dominant genes for this trait, followed by 4072 under irrigated conditions. The maximum recessive genes were exhibited by LU26S, followed by Inqlab 91. The regression line cut the Wr axis above the point of origin showing additive type of gene action with partial dominance. The Vr/Wr graph (Fig. 9b) exhibited that the variety Inqlab 91 possessed the maximum dominant genes followed by Pak.81. The maximum recessive genes were exhibited by the variety LU26S. Since the regression line cut Wr axis below the point of origin presence of over dominance type of gene action may be speculated with some confidence. These results are in conformity with the findings of Chowdhry *et al.* (1992) who reported non-additive genetic effects for grains per spike. Many other researchers like Sharma and Ahmad (1980), Lonc (1989), Alam *et al.* (1991), Khan *et al.* (1992), Chowdhry *et al.* (1997) and Munir (1997) reported a partial dominance type of gene action as revealed in the present study under irrigated conditions.

1000-grain weight: The graphical representation (Fig. 10a) reserved that the LU26S had the maximum dominant genes controlling this trait under irrigated conditions. It was followed by genotype 4943. The maximum recessive genes were contributed by the genotype 4072, followed by Rohtas 90. The regression line intercepted the Wr axis above the point of origin showing the presence of additive effects along with partial dominance type of gene action. The graph (Fig. 10b) revealed that the cultivar 4943 had the maximum dominant genes for this trait under drought stress conditions, followed by LU26S. The maximum recessive genes were contributed by the variety Rohtas 90, followed by 4072. The regression line cut the Wr axis above the point of origin showing partial dominance involved with strong additive effects (Sharma and Ahmad ,1980; Lonc, 1989; Chowdhry *et al.* 1992 and Munir, 1997). However, contradictory results were reported by Lonts (1984) who reported the overdominance for 1000-grain weight.

Biomass per plant: The Vr/Wr graph (Fig.11a) exhibited that cultivar 4943 possessed maximum dominant genes for biomass per plant followed by Inq 91 under irrigated conditions. The maximum recessive genes were present in Rohtas 90, followed by Pak.81. The regression line cut the Wr axis below the point of origin, showing over dominance type of gene action for this trait. Under drought stress conditions, the graphical representation (Fig. 11b) exhibited that for this trait the cultivar Inqilab-91 had maximum dominant genes, followed by Pak. 81. The maximum recessive genes were noted in the variety Rohtas 90, followed by LU26S. The regression line cut the Wr axis above the point of origin, showing the partial dominance type of gene action, compared to average of all array. Over dominance was present in the inheritance of biomass per plant under irrigated conditions. Srivastava and Nema (1993) have also reported similar results.

Grain yield per plant: The Vr/Wr graph (Fig. 12a) indicated that genotypes 4943 possessed the maximum dominant genes for grain yield per plant under irrigated conditions, followed by Inqlab 91. The maximum recessive genes were exhibited by Rohtas 90, followed by Pak.81. The regression line intercepted the Wr axis below the point of origin showing over dominance type of gene action for this trait. A graphical representation (Fig. 12b) of the results indicated that variety Inqlab 91 possessed the maximum dominant genes among the genotypes studied, followed by the genotype 4072. The maximum recessive genes for grain yield per plant were present in LU26S, followed by Rohtas 90. The regression line intercepted the Wr axis above the point of origin showing the partial dominance type of gene action along with additive genetic control of the character.

Over dominance was observed for grain yield per plant under irrigated conditions. These results are in agreement with those of Sharma and Ahmad (1980), Lonts (1984),
Chowdhry *et al.* (1992), Srivastava and Nema (1993), Chowdhry *et al.* (1997) and Munir (1997) who also reported over dominance for grain yield per plant. Under drought stress conditions partial dominance was observed for grain yield per plant, therefore, similar results were reported by Lonc (1989) and Alam *et al.* (1991) inasmuch as they reported partial dominance for grain yield per plant.High coefficients of correlation between Yr and Wr+Vr with positive sign were observed for days to heading and tillers per plant under both environments (Table 1) which depicted that these traits were controlled by recessive genes. These results confirmed by the findings of Lonts (1984) and Lonc (1989) who also reported the recessive genes for tillers per plant. Negative sign with high coefficient of correlation were recorded between Yr and Wr+Vr for leaf venation, flag leaf area, specific flag leaf weight, plant height, spike length, grains per spike, 1000-grain weight, biomass per plant and grain yield per plant indicating that dominant genes involved for the inheritance of these traits under both environments. Similar result fined support from the results of Lonts (1984), Lonc (1989) and Gill *et al.* (1986). But Lonc (1987) reported the recessive genes for spike length and grains per spike.

It is concluded from the present results that the presence of additive type of gene action alongwith partial dominance for stomatal frequency, specific flag leaf weight, days to heading, plant height, spike length and 1000-grain weight would suggest the selection in early segregating generations for these traits. Whereas effective selection in the early segregating generations would be difficult for leaf venation, flag leaf area, tillers per plant, grains per spike, biomass per plant and grain yield per plant due to the presence of overdominance under their respective environment. The presence of predominantly large amount of non-additive gene action for tillers per plant, grains per spike, biomass per plant and grain yield per plant would necessitate the maintenance of heterozygosity in the population. Such genetic variability is non-fixable.

able 1: Correlation coefficients between Yr and Wr+Vr and 'b' value for grain yield and other morpho-physiological traits in bread wheat under irrigated and drought stress conditions.

raits	Irrigated conditions		Drought stress conditions	
	Correlation coefficient	Regression coefficient 'b"	Correlation coefficient	Regression coefficient 'b"
tomatal frequency	8150.	1.959	-0.749	-2.073
eaf venation	-0.673	-0.145	-0.596	-0.175
lag leaf area	-0.356	-0.671	-0.968	-0.630
pecific flag leaf weight	-0.733	-0.294	-0.530	-0.092
ays to heading	0.972	1.913	0.671	1.010
illers per plant	0.189	0.190	0.417	0.248
lant height	-0.693	-0.525	-0.745	-1.596
pike length	-0.904	-0.610	-0.806	-0.342
rains per spike	-0.584	-1.406	-0.910	-4.234
000-grain weight	-0.811	-1.623	-0.727	-0.837
omass per plant	-0.486	-3.781	-0.587	-1.282
rain yield per plant	-0.484	-2.117	-0.213	-0.204

enotype 4943 and Inqlab 91 had the maximum dominant genes for rain yield and most of its components under irrigated and drought ress conditions. Dominant genes involved in the expression of leaf enation, flag leaf area, specific flag leaf weight, plant height, spike ngth, grains per spike, 1000-grain weight, biomass per plant and ain yield per plant under both environments.

is also evident that for flag leaf area, tillers per plant, grains per pike, biomass per plant and grain yield per plant, overdominance pe of gene action changed into additive dominance or vice versa ith the change of environmental conditions. The dominance lations of the genes controlling the grain yield and other morpho-hysiological traits thus depend on the environment in which they e measured.

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