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Studding the genetic control of the bread quality related traits of wheat using Hayman graphical method

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ABSTRACT

In order to Hayman graphical analysis of some Quality related traits of bread wheat via diallel crosses, the F_2 *genotypes of a* 5×5 *half diallel with their parents were cultured in normal irrigated and terminal drought conditions at Islamic Azad University, Ardabil, Iran in 2009. Experimental design was randomized complete block design with two replications.The grain protein content, loaf volume, grain hardness, SDS-sedimentation volume, thousand kernel weight and hectoliter weight were measured. Combined analysis of variance showed significant differences among genotypes for all the studied traits indicating the presence of enough genetic diversity. Hayman's graphs revealed over-dominance effects for grain protein content, loaf volume, thousand kernel weight and hectoliter weight in normal condition and hectoliter weight in water stress condition. These graphs also showed partial dominance for grain hardness and SDS sedimentation volume in normal condition.*

Keywords: Bread wheat, Bread quality, Diallel cross, Hayman graphical method

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INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is the major staple food source for a large part of world population and is used to produce a wide diversity of baked food products. Therefore, wheat and its productions are the main food sources for human. According to Bushuk [1] the quality depends on the protein content of wheat. Fowler et al. [2] were introduced dough development speed, grain hardness and grain protein content, as the three main variables in predicting bread quality properties. Branlard and Dardevet [3] stated that there is a strong correlation between the SDS sedimentation volume and qualitative properties of bread, so that high sedimentation rates lead to higher gluten strength. Therefore SDS sedimentation volume is a suitable criterion to predict the wheat bakery properties. Belderok and Donner [4] reported that changes in grain moisture can affect the water mill and bakery properties.

Knowing the type of action of genes that associated with bakery quality of wheat is very important in selecting appropriate breeding method [5]. One of the most common methods for determining the effects of genes is diallel crosses design. Principals of diallel have presented by Jinks and Hayman [6] and Griffing [7]. The bakery value is a very complex character and quality of each cultivar can not be expressed by a trait [8]. In bakery quality evaluation, we can use some indirect methods as a criterion to estimate the value of bakery [9]. Grain protein content, grain hardness, hectoliter weight, loaf volume, SDS sedimentation volume and Near Infrared Reflectance Spectroscopyor NIRS are indirect methods used to determine the quality of bread wheat cultivars [10].

MATERIALS AND METHODS

Five wheat cultivars (Alvand, Gascogen, Pishtaz, Sabalan and Sisson) were selected to prepare F_1 crosses based on a one-way diallel mating design. F_1 seeds from each of the 10 crosses were grown and self-pollinated to produce F_2

seeds. Genotypes (Including 10 F_2 and 5 parents) were evaluated in normal irrigation and terminal drought conditions at Islamic Azad University, Ardabil, Iran in 2009. Experimental design was randomized complete block design with two replications. Each plot consisted of three rows 1m long. The interrow and interplant spacings were 20 and 5cm, respectively. Under drought condition, irrigation was stopped before flowering stage and to prevent rain, plastic cover was used. Grain protein content, loaf volume and grain hardness were measured using Inframatic devices. SDS sedimentation test was conducted according to the standards of the International Association for Cereal Science and Technology and methods of American Association of Cereal Chemists (ACC). Before ANOVA analysis, assumptions of normal distribution of deviations, additive effects of genotype and block and homogeneity of variances were approved for all traits. Average degree of dominance was estimated using Verhalen et al. [11] method. For combined analysis of variance, and drawing Hayman graphs, software's EXCEL, SAS 16 and DIAL 98 were used.

RESULTS AND DISCUSSION

Combined analysis of variance showed that there are significant differences among genotypes with respect to grain hardness, SDS-sedimentation volume, thousand kernel weight and hectoliter weight at %1 probability level and for grain protein content and loaf volume at %5 probability level (Table 1). Drought stress affected only on the thousand kernels weight (at %5 probability level). Gaines et al. [12] have reported similar results in their research. Interaction between genotype and environment only for hectoliter weight was significant (at the %1 probability level). Coefficient of variation (CV) values indicated that experiment has been done accurately.

Table 1 - Analysis of variance in complex traits in wheat genotypes with or without stress

		Means square					
Source	DF	Grain protein content	loaf volume	Grain hardness	SDS-sedimentation volume	Thousand kernel weight	Hectoliter weight
Environment	1	0.160^{ns}	3435.267^{ns}	1.350^{ns}	224.267^{ns}	159.740^{*}	12.096^{ns}
Replication(Environment)	2	0.412	3973.333	4.238	35.267	7.782	6.699
Hybrid	14	0.137^{*}	1116.100	5.552^{**}	87.781^{**}	72.031^{**}	19.619^{**}
Hybrid× Environment	14	0.114^{ns}	1215.195^{ns}	0.814^{ns}	20.338^{ns}	13.887^{ns}	9.072^{**}
Error	28	0.037	428.619	1.855	28.231	7.388	2.970

**, ** and ns significant at $p \leq 0.05$, $p \leq 0.01$ and non-significant, respectively*

In order to identify the type of gene effects in the genetic control of traits, Hayman graphical analysis was performed. Figures 1 to 6 are showing the regression lines of the Wr/Vr and distribution of parents along it for different traits. The average degree of dominance for each trait is presented in order to compare it with the graphics. Figure 1 is showing grain protein graph in normal condition. Considering that regression line has intercepted the Wr axis below the point of origin, gene action in the genetic control of this trait is over-dominance [13]. The average degree of dominance for this trait is 1.18 which is confirming it. Distribution of varieties along the regression line showed that Soisson had maximum number of dominant genes and Sabalan carried maximum number of recessive genes for grain protein content.Genetic control of loaf volume in normal condition was over-dominance (Fig. 2). Estimation of average degree of dominance of genes ($\overline{D} = 1.26$) revealed similar result. The distribution of parents along the regression line showed that Sabalan had maximum number of dominant genes and Gascogen had maximum number of recessive genes. Figure 3 shows the grain hardness regression line in the normal condition. Graph showed that the regression line crossed the Wr-axis at the positive part (top of the axes), which is an indication for the incomplete or partial dominance gene action. The average degree of dominance $\left(\overline{D}\right)$ for this trait was 0.51, which is confirming it. Soisson had the most dominant genes and Sabalan had the most recessive genes for grain hardness. Genetic contol of SDS sedimentation volume in normal condition was partial dominance (Figure 4). Alvand and Sabalan had the more dominant genes, while Sisson and Pishtaz had the more recessive genes.

Regression line of the thousand kernel weight interrupted the Wr axis in the positive part and $\overline{D}$ value was 1.22. So genetic control of this trait is over-dominance (Figure 5). Distribution of parents along the regression line showed that Alvand had the highest frequency of dominant genes and Sisson had the most recessive genes for controlling thousand kernel weight.

Figures 6 and 7 are showing the hectoliter weight in normal and drought stress conditions respectively. Considering that regression lines have intercepted the Wr axis below the point of origin, genes action in the genetic control of these traits is over-dominance. Also the average degrees of dominance for both of them are more than one ($\overline{D} =$ 2.02 and $\overline{D} = 1.71$). Alvand cultivar had maximum number of dominant genes and Gascogen and Pishtaz carried maximum number of recessive genes for controlling the hectoliter weight in normal condition. However for hectoliter weight in drought condition Alvand had the most recessive genes, while other varieties had more dominant genes.

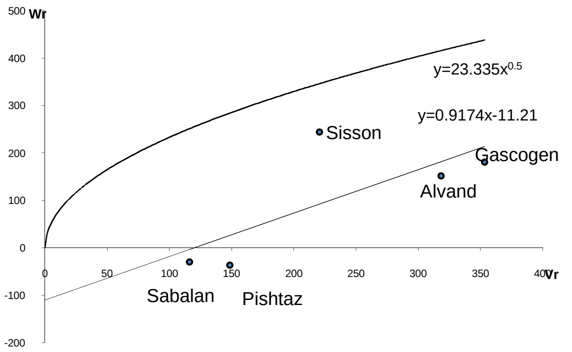

Figure 2.Wr/Vr graph of bread volume in non-stress conditions ($\overline{D}$=1.26)

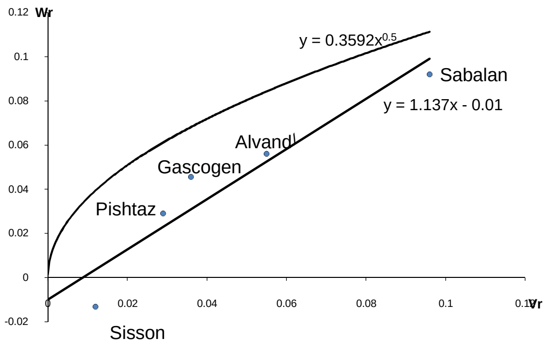

Figure 1.Wr/Vr graph of protein yield in non-stress conditions ($\overline{D}$=1.18)

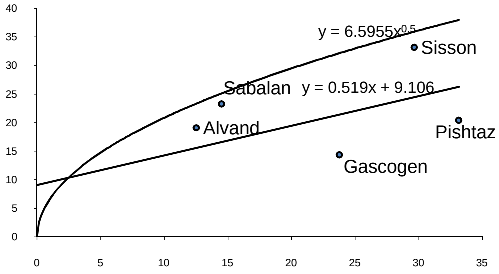

Figure 4.Wr/Vr graph of SDS-sedimentation volume in normal condition ($\overline{D}$=0.58)

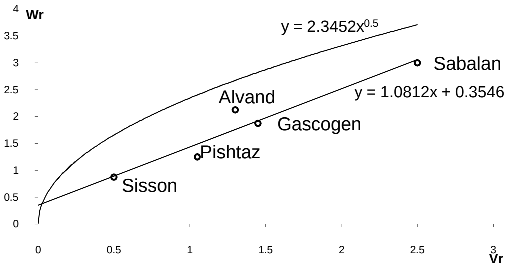

Figure 3.Wr/Vr graph ofgrain hardness in non-stress conditions ($\overline{D}$=0.51)

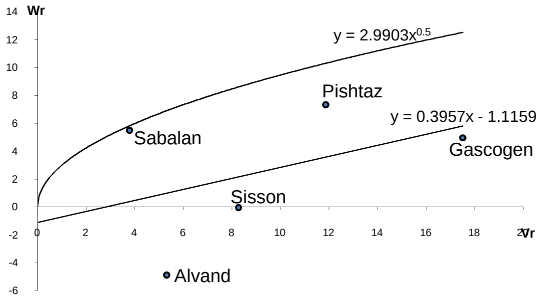

Figure 6.Wr/Vr graph ofhectoliter weight in non-stress conditions ($\overline{D}$=2.02)

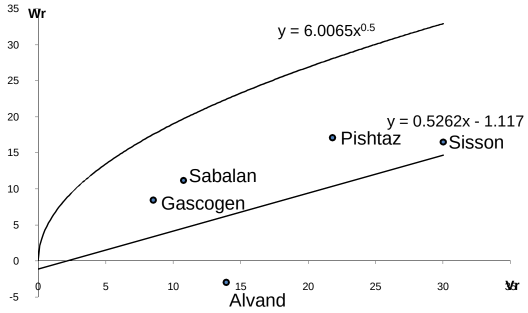

Figure 5.Wr/Vr graph ofthousand kernel weight in non-stress conditions ($\overline{D}$=1.22)

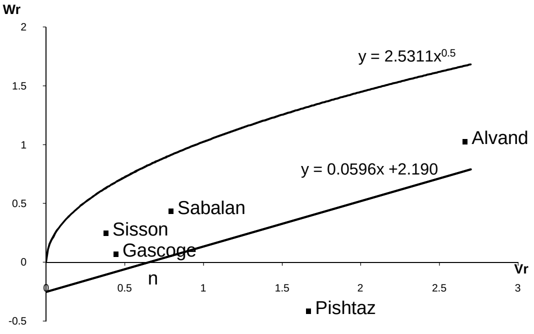

Figure 7.Wr/Vr graph ofhectoliter weight in water stress Conditions ($\overline{D}$=1.71)

CONCLUSION

Considering that in this research, genetic control of the most of the traits was over-dominance, so parental cultivars of this study can be used in the crosses to product the transgressive segregated genotypes for using in plant breeding programs. On the other hand if the non-additive effects of the genes played a considerable role in some traits, selection in early generations is not recommended. Thus, hybridization method with selection in the advanced generations can be useful.

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