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GENOTYPE-ENVIRONMENT INTERACTION STUDIES IN WHEAT (*TRITICUM AESTIVUM* L.) BY PRINCIPAL COMPONENT ANALYSIS IN DISTRICT POONCH AZAD JAMMU AND KASHMIR PAKISTAN

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Key words: Wheat, Principal component analysis, Genotype-environment interaction, Stability

Abstract

Ten wheat genotypes were grown to analyze the G × E interaction effects and evaluate the stability of yield and yield component at three different locations. The yield stability of ten wheat genotypes was investigated through genotype × environment interaction by using principal component analysis (PCA) techniques at three different locations. In PCA, first two principal components PC1 and PC2 were used to create biplot diagrams. Visualizing the mean yield and stability of the genotypes indicated that genotypes Saleem-2000, Haider-2000 Aquab-2000, Wafaq-2001 and NARC-2010 were suitable in priority sequence for adaptation at three locations. All other genotypes showed great genotype × environment interaction with less yields than mean yield. The vector view of biplot showed that Rawalakot and Arja were positively correlated on the bases of spike length, biological yield, grain yield and harvest index, but had no relationship with Hajira both of the two year. But on the bases of spikelet per spike, grains per spike and 1000-grain weight Hajira positively correlated in one year but in the next year Rawalakot and Arja showed positive association. It was concluded that these five genotypes showed high mean yield and high yield stability across all these environments and hence recommended for this area.

Introduction

Stable wheat production is a major concern in rain fed areas that are affected by different environmental factors. Growing of adapted cultivars with high yield stability is an effective strategy for reducing environmental effects on wheat production in rain fed areas. To develop suitable cultivars, evaluation of improved genotypes is a critical phase in breeding programs, because great numbers of genotypes need to be evaluated across locations over several years. Studying the response of genotype under different conditions may significantly increase their productivity potential and performance Kang (2002). Environmental factors are not stable across locations and years that ultimately affect the stability of wheat genotype. Grain yield is the outcome of the genotype, environment and G × E interaction Hamam *et al*. (2009), Sial *et al*. 2007). Differential responses of genotypes from one environment to another are known as genotype by environment (G × E) interactions. G × E interaction is very important issue to plant breeders, for the improvement of breeding material because grain yield stability is reduced in diverse environments Loffler *et al*. (2005). The G × E interaction complexity, mostly in environmental (soil fertility, moisture, temperature and day length) factor can reduce grain yield stability. In multi-environmental trials, G × E interactions limit plant breeding progress for broad as well as specific adaptation Dreccer *et al.* (2008). The new improved genotypes are influenced by an understanding of G × E interaction and the degree to which the test locations are represented in multi-environment trials Podlich and Cooper (1998).

In crop breeding programs, the first objective of plant breeders is the development of genotypes that are stable over diverse environments (Farshadfar 2011). To estimate yield stability multi-environment trials (MET) are conducted under diverse environmental conditions. A genotype which is grown in different environmental conditions will commonly show some fluctuations in performance of yield Yan *et al*. (2000), Farshadfar *et al*. (2012). To understand the patterns of G × E, several methods have been designed, like joint regression (Finlay and Wilkinson 1963, Eberhart and Russel 1966, genetic correlation Burdon 1977) and additive main effects and multiplicative interaction (AMMI) Gauch (1992). To analyze MET data, these methods are frequently used and also applied to study the G × E interaction of wheat (Farshadfar *et al*. 2003, Mohammadi and Amri 2008).

Yan *et al*. (2000) proposed a new method known as genotype and genotype-environment interaction (GGE) bi-plot which is used for graphical display of G × E interaction in MET data with a lot of advantages. GGE bi-plot analysis is an useful method which is based on principal component analysis (PCA) to completely explore MET. It shows the relationships between the test environment through visual examination, genotypes and the G × E interactions. It is successful tool for analyze mega-environment and genotype evaluation and environment evaluation Ding *et al*. (2007).

The objective of the present study were to evaluate the stability and also analyze the G × E interaction effects on yield and yield component of ten wheat genotypes in three environment of rain fed conditions of district Poonch Azad Kashmir, Pakistan.

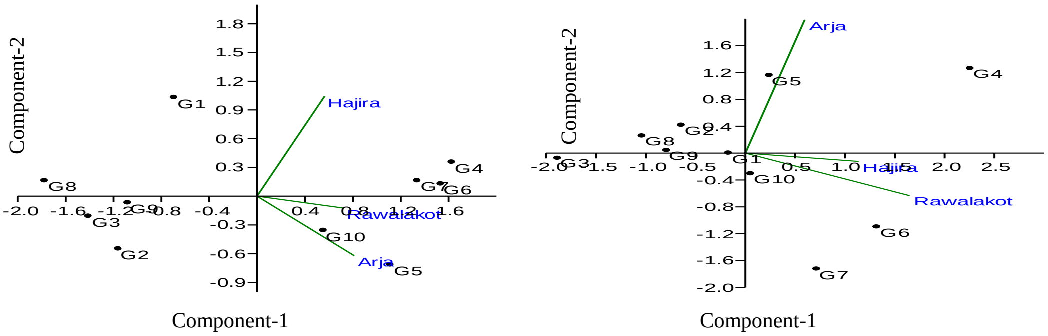
Materials and Methods

This study was performed at three different locations of district Poonch Azad Jammu and Kashmir during two consecutive years 2010-11 and 2011-12. These locations were Arja, Rawalakot and Hajira. Arja is located at latitude of 33^{0}’ 58-22 N, longitude 73^{0}’ 40-43 E” and an altitude of 2624 feet. Rawalakot is situated 33^{0}’ 51-32N, 45^{0}’34-34.95E and an elevation of 5265 feet while Hajira is located at 33^{o}’46-18.12, 73^{o}’ 53-45.96E and an altitude of 3034 feet. Seed of ten wheat (*Triticum aestivum* L.) genotypes *viz*., Chakwal-86(G1), Chakwal-97(G2), Marwat-J0 (G3), Saleem-2000 (G4), Haider-2000 (G5), Auqab-2000 (G6), Wafaq-2001 (G7), GA-2001 (G8), AS-2003 (G9) and NARC-2010 (G10) were used. The experiment was designed by using RCBD with three replications. All the data were subjected to the computer Software PAST to analyze the principal component analysis.

Results and Discussion

The ranking of ten wheat genotypes based on their yield and yield components for stability performance over three locations of Poonch Division Azad Kashmir are shown (Fig. 1). It has been reported that in GGE bi-plot PC1 estimated the genotype (mean performance) and PC2 estimated the G×E interaction with each genotype, that measure the instability of genotype (Yan *et al*. 2000, Yan and Rajcan 2002). In these figures the line passing through b-iplot origin is called average environment coordinates (AEC) that is defined by the average PC1 and PC2 scores of all environments Yan and Kang (2003). The genotypes which are close to the center of the AEC on the right side, indicates higher mean yield. The line that is passing through the origin and is perpendicular to the AEC shows the stability of genotypes. The left side of bi-plot origins manifests greater G × E interaction and decreases the stability. The ideal genotypes are selected with high mean yield and high stability. The genotypes which were on right side of the perpendicular line have yield performance greater than mean yield and the genotypes on the left side of perpendicular line showed less yields than mean yield.

According to number of spikelet per spike high mean yield and high stability was observed in G6, G7, G4 and G10 while low stability with high mean was recorded in G5 in Fig. 1a. All other genotypes showed great G × E interaction with less mean yield and low stability. The genotype G10 and G5 best adapted the Arja while G6, G7, G4 and G10 adapted the Rawalakot but none of genotypes was adapted the Hajira. Arja and Rawalakot showed negative correlation with Hajira. In the next year during 2011-12 high mean yield and high stability was calculated in G10 but high mean yield with low stability was observed in G5, G4, G6 and G7 in Fig.1b.

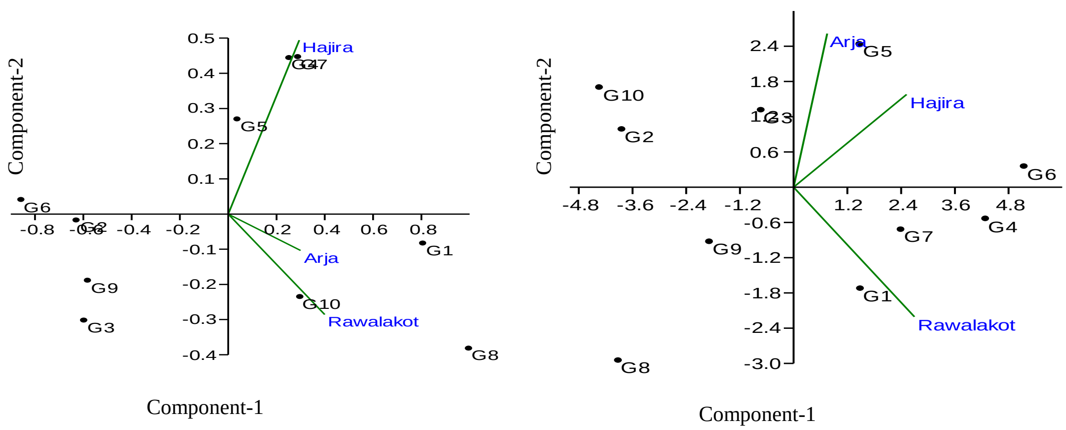


1a PC1= 85.559 PC2=11.672 **1b PC1= 60. 683 PC2= 34.417**

Figs 1a-b. a. Principal component analysis of G × E regarding number of spikelets per spike. b. Principal component analysis of G × E regarding number of spikelets per spike.

G5 was well adapted to Arja but G6 was best at Rawalakot. All other genotypes showed great G × E interaction with less yields and poor stability. Hajira and Rawalakot showed positive association with each other but negative correlation with Arja.

On the basis of number of grains per spike G4 and G6 showed high mean yield with high stability but low stability with high mean was observed in G5 and G10 in Fig. 2a. G5 was best adapted the Hajira while G6 at Arja and G6 and G10 was best genotype in Rawalakot. Remaining six genotypes showed less mean yields with poor stability but great G × E interaction. In the next year high mean yield and high stability was recorded for G6, G4 and G7 while high mean yield with low stability was observed for G1 and G5 as shown in Fig. 2b. The genotype G5 was the best genotype at Arja and G1 at Rawalakot. Correlation study showed the positive association with Arja and Hajira.



2a. PC1=58.249 PC2=34.738 **2b. PC1= 74.948 PC2=17.337**

Figs 2a-b. a. Principal component analysis of G × E regarding number of grains per spike. b. Principal component analysis of G × E regarding number of grains per spike.

Based on thousand grains weight (TGW) high mean yield with high stability was observed in G7 and G10 but G4 and G8 showed less stability with high mean yield in Fig. 3a. Other genotypes showed greater G × E interaction with reduced stability and less mean yield. Genotype G4 was the best genotype at Arja and Hajira while G8 was the best genotype at Rawalakot (Fig. 3a). The correlation study of these test locations showed a positive association between Hajira and Arja but Rawalakot showed a negative correlation with Hajira and Arja. In the next year in Fig. 3b G1 showed high mean yield with high stability whereas high mean yield with less stability was recorded in G5, G10, G4, G7 and G8. All other genotypes which are on the left side of perpendicular line showed greater G × E interaction with less mean yields and less stability.

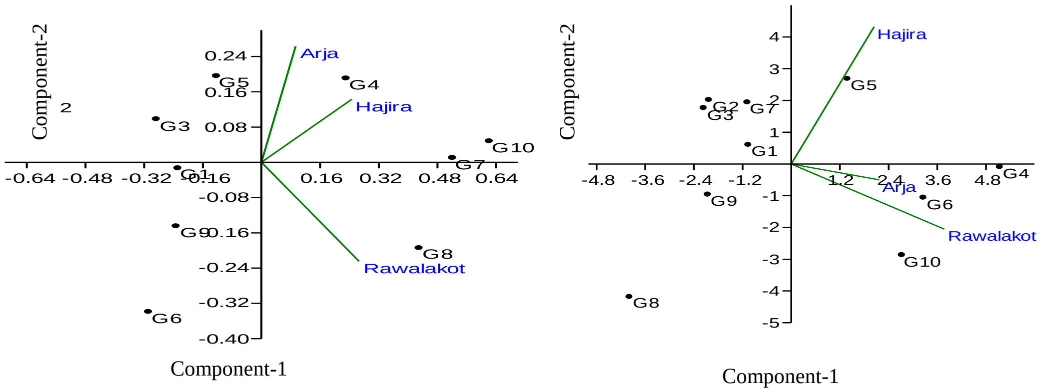


Fig. a. PC1= 77.398 PC2= 13.386 **Fig. b. PC1=80.32 PC2=17.47**

Figs 3a-b. a. Principal component analysis of G × E regarding 1000-grain weight. b. Principal component analysis of G × E regarding 1000-grain weight.

Genotypes G7, G4 and G5 were the best at Hajira while G10 and G8 were the best at Rawalakot but none of the genotypes grew well at Arja. A correlation study of these test locations showed positive association with Arja and Rawalakot but negative with Hajira (Fig. 3b).

On the basis of biological yield G10 showed highest stability with high mean yield whereas high mean yield with stability was observed in G4 and G8 in Fig. 4a. Great G × E interaction was observed in other seven genotypes with less mean yield and less stability. The G10 was the best genotype at the Arja while G5 at Rawalakot and G4 at Hajira. In the next year (Fig. 4b) G2, G5, G4 and G10 showed high mean yield with high stability but high mean yield with low stability was observed in G7. Genotype G7 was the best genotype at Hajira whereas G2 and G5 at Rawalakot and G10 at Arja. A positive association was recorded at Hajira and Rawalakot but Arja showed a negative correlation with Hajira and Rawalakot (Fig. 4b).

According to grain yield (GY) high mean yield with highest stability was observed in G6, G10, G5 and G4 while G7 and G9 showed less stability with high mean yield (Fig. 5a). Great G × E interaction was observed in G3, G1, G8 and G2 with less mean yield and less stability. Genotypes G9 and G4 were best at Rawalakot and Arja whereas G7 in Hajira. A correlation study showed that a strong positive association was observed at Rawalakot and Arja but Hajira showed negative correlation with Arja and Rawalakot. In the year 2011-2012 as shown in Fig. 5b high mean yield with highest stability was observed in G10, G4 and G6 while G7 showed high mean yield with less stability. G1, G2, G3, G9, G8 showed great G × E interaction with less mean yield and reduced stability. Genotypes G7 and G5 were the best at Hajira while G4 and G6 were best at Rawalakot but none of the genotypes was best in Arja.

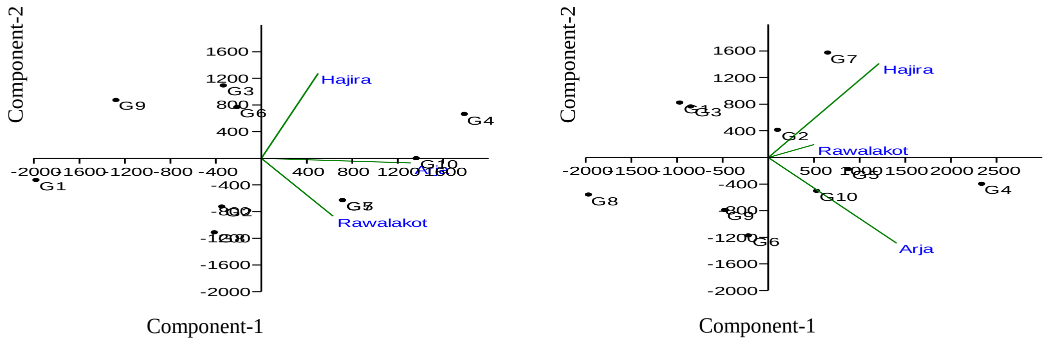


Fig. 4. a. PC1 = 60.103 PC2 = 28.505 **Fig.4.b. PC1 = 57.284 PC2 = 29.919**

Figs 4a-b.a. Principal component analysis of G × E regarding biological yield. b. Principal component analysis of G × E regarding biological yield.

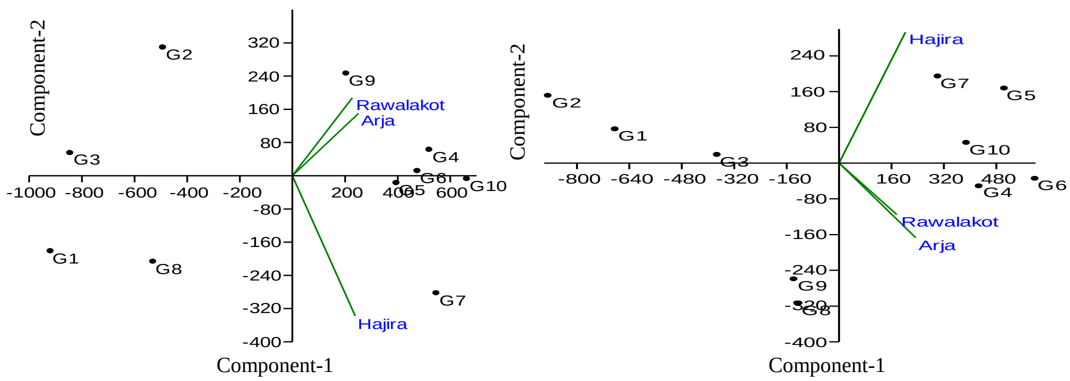


Fig. 5. a. PC1 = 88.017 PC2 = 8.007 **Fig. 5b. PC1=87.342 PC2 = 9.355**

Figs 5a-b. a. Principal component analysis of G × E regarding grain yield. b. Principal component analysis of G × E regarding grain yield.

Stable performance of wheat (*Triticum aestivum* L.) genotypes in multi-environment is major concern in crop breeding programs. Genotype evaluation and mega-environment identification for yield stability for ten wheat genotypes was investigated through genotype (G) and genotype × environment (GE) interaction by using the bi-plot (GGE biplot) technique. The principal component analysis was performed and first two principal components (PC1 and PC2) were used in the present study. The bi-plot technique (Gabriel 1971) was extended by Kempton (1984) and Zobel *et al*. (1988) for analyzing the stability of grain yield. In bi-plot technique a scatter plot is produced that displays the two data-set graphically by using the both factors in such a way, that the association between these factors can conceal the performance of the individual genotypes. Recently, the broad usefulness of bi-plot was proposed by Yan *et al*. (2000) and reported that the GGE bi-plot is an efficient procedure which is based on principal component analysis (PCA) to fully investigate the multi-environment trial (MET) data. It shows the relationship between the test environments, genotypes and G × E interaction through visual examination. The G × E interaction biplot technique is a simple method that gained popularity in recent years and is used to analyze the data from multi-environment. It has powerfully captured the consideration of plant breeders and successfully used to determine the relationships between genotypes and G × E interaction effects (Yan *et al*. 2007, Yan and Holland 2010). The bi-plot is useful tool for exploring G×E interaction and analyzing yield stability. According to these stability parameters G4, G5, G6, G7 and G10 were the most stable genotypes with high mean yield and location Arja and Rawalakot showed strong positive correlations. Our result was accordance with the previous finding of Dehghani *et al*. (2006, 2009), Farshadfar *et al*. (2012), Mohmmaddi *et al*. (2012), Sabaghnia *et al*. (2008).

Genotypes Saleem-2000, Haider-2000, Aquab-2000, Wafaq-2001 and NARC-2010 were most adapted and stable with high mean yield across these three locations of district Poonch Azad Jammu and Kashmir Pakistan and consequently recommended for these areas.

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