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ADAPTATION AND STABILITY OF PROMISING WHEAT GENOTYPES FOR YIELD UNDER RAIN FED CONDITIONS OF HIGHLAND BALOCHISTAN

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ABSTRACT

Five wheat genotypes including local wheat as a check were tested for grain yield stability at three different locations under rained conditions during 2006-07 in highland of Balochistan, Pakistan. These genotypes were exposed to different soil type, soil fertility, moisture levels and temperature. The G × E interaction mean squares were non-significant for grain yield. The mean square due to pooled deviations were, however highly significant indicating significant difference among five genotypes for non liner response. The overall mean grain yield performance of genotypes across environments ranged from 1198 to 2203 kg/ha. The stability parameters indicated regression coefficient (bi) value ranging from 0.998 in AZRC-3 to 1.004 in local wheat cultivar. Cultivar AZRC-3 having by values close to unity with higher grain yield showed consistent performance under different environments and considered as stable and widely adopted. This cultivar also showed the ideal stable performance with regard to mean grain yield of 2203 kg/ha, regression coefficient value of 0.998 and dispersion value of 0.002 followed by cultivar AZRC-2 (1999 kg/ha) with regression coefficient value of 0.999 and dispersion value (0.000). Based on bi and S^2d values cultivar AZRC-4 was found to be stable for specific adaptation in favorable environments and produced good yield with regression coefficient $\geq$ 1.0. Whereas, cultivars AZRC-1, AZRC-2 and AZRC-3 having values close to unity with higher grain yield showed consistent performance over different environments and could be considered as stable and widely adapted.

Key words: Moisture Stress, Wheat Adaptability, G x E Interaction.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the major cereal crop in Pakistan on which the food security rests. It covers an area around 9.13 million hectares with the annual production near 23.31 million tons in Pakistan (Anon.,2010). Environmental factors such as abiotic (soil, fertility, moisture, temperature, sowing time, day length) and biotic (diseases and pests) are not consistent across years and locations which ultimately affect the yield of wheat genotypes. Grain yield is the function of genotype, environment and genotype x environment interaction (Arain *et al*., 2001; Hamam *et al*., 2009; Sial *et al*., 2007). Water stress is one of the main abiotic stress and an important factor which reduces the yield of cultivated plants in semi-arid agricultural land (Konooka *et al.*, 2007). Response of plants to water stress depends on several factors such as developmental stage, intensity and duration of stress and cultivar genetics (Eskandari and Kazemi, 2010). Water deficit/drought affects every aspect of plant growth and the yield, modifying the anatomy, morphology, physiology, biochemistry and finally the productivity of crops (Hafiz *et al.*, 2004). High grain yield has been the main aim in bread wheat improvement and the wheat breeders are concentrating to improve the yield potential of wheat by developing new genotypes (Erkul *et al.*, 2010; Kusaksiz and Dere, 2010). Grain yield and its stability in various regions where there are environmental stresses have been used as a main criterion for selection and presentation of genotypes (Trethowan and Reynolds, 2007). Clarke *et al.* (1991) reported that the selection based on physiological and morphological components of the yield is more effective in breeding programme. Many physiological, morphological and developmental traits have been suggested to be useful in improving drought tolerance (Ludlow and Muchow, 1990; Quarrie *et al.*, 1999; Wright and Rachaputi, 2004). But breeding for specific and sub-optimal environments involves a deeper understanding of yield determining process (Moayedi *et al.*, 2010).

Drought is one of the most important factors which limit the production of crops including wheat in the world. This topic is more important in arid and semi-arid regions of the world (Alaei *et al.*, 2011), where many developing and under developed countries happen to fall. In this region, during drought period water potential in rhizospher becomes sufficiently negative and reduces the water availability to sub-optimal level for plant growth.

Genotypes x environment (G x E) interactions are of major concern to plant breeders, developing cultivars for specific target regions. For a genotype to be successful, it must perform well across the range of environments. Genotype x environment interaction studies thus provides a basis for selection of genotypes that suit for general cultivation and others for the specific area and under defined environments (Nachit *et al.*, 1992; Ahmed *et al.*, 1996; Peterson *et al*., 1997; Yan and Rajcan, 2002; Khan *et al*., 2007). The Adaptability of variety/Genotype over diverse environment is usually tested by degree of its interaction with different environments under which it is planted. A crop genotype is considered to be the most favorable one if it has a high mean yield and a consistent performance when grown across diverse locations and years (Gauch *et al.*, 2008). Plant breeders usually evaluate a series of genotypes across environments before a new improved genotype is released for production to farmers (Naghavi *et al.*, 2010). Therefore, identification of genotype(s) that perform consistently across environments should be emphasized (Annicchiarico, 2009). In most of the genotype evaluation trials, GE interaction is observed as a common phenomenon (Ceccarelli *et al.*, 2006). The G x E interaction complicates selection of truly superior genotypes in breeding and performance testing programmes. Eberhart and Russel (1966) proposed a model to test the stability of varieties under various environments. They defined a stable variety as having unit regression over the environments (bi = 1.00) and minimum deviation from the regression ($S^2d = 0$). Therefore, a variety with a high mean yield over environments, unit regression coefficient (bi = 1) and deviation from regression as small as possible ($S^2d = 0$) will be a better choice as a stable variety. The objective of the present study was to identify the promising wheat genotype for wide and specific adaptation based on grain yield performance under rainfed conditions.

MATERIALS AND METHODS

Five promising wheat genotypes were selected on the basis of their better performance under rainfed conditions at Balochistan Agricultural Research Centre Quetta, Pakistan. These genotypes AZRC-1, AZRC-2, AZRC-3 and AZRC-4 along with local variety (local white) as Check were evaluated for wide and specific adaptation at three different locations (Qilla Saifullah, Loralai and Mastung districts) under moisture stress (rainfed) conditions during 2006-2007. These locations were heterogeneous for soil type, temperature and precipitation. Trials at each location were conducted in randomized complete block design (RCBD) with four replications. Plot size was kept 9 m^2 with six rows (5 m long and 30 cm apart). Sowing was carried out in the second week of October at each location. Nitrogen and phosphorus were incorporated in the soil during the seed bed preparation @ 90:60 kg/ha. No irrigation was applied during the growing season. Four rows (plot size 5 m^2) were harvested to determine grain yield as a direct selection criterion for drought tolerance. Parentage of the studied inbred lines is given in Table 1. Statistical Model of Eberhart and Russell (1966) was used for stability analysis.

RESULTS AND DISCUSSION

The combine analysis of variance (Table-2) revealed that there were significant differences among environments and genotypes for grain yield, indicating the presence of variability in genotypes as well as diversity of growing conditions at different locations. The G x E interaction was highly significant, reflecting the differential response of genotypes in various environments (Zubair *et al.*, 2001). Some genotypes showed wide adaptation and stability over a range of environments, while others exhibited specific adaptation to the specific environments.

The grain yield data of wheat genotype at different locations is shown in Table 3. The highest mean grain yield was obtained at location Akhterzai (Qila saifullah) (2347 kg/ha) followed by Naliwalizai, Loralai (2266 kg/ha) and the lowest at Siddiqabad (Mastung) (Table 3). The difference in the grain yield is due to the variation in environmental conditions (temperature and rainfall) at test locations. The location of Naliwalizai remained under moisture stress round the year. Genotype AZRC-3 gave the highest mean grain yield (2203 kg/ha) across the locations followed by AZRC-2 (1999 kg/ha.). The highest grain yield was produced by cultivar AZRC-3 (2973 kg/ha) at Akhterzai (Qila saifullah) followed by AZRC-2 (2617 kg/ha) and AZRC-1 (2613 kg/ha) on the same location, whereas, local wheat produced the lowest grain yield (1142 kg/ha) at Naliwalizai. A significant G x E interaction may be a non-cross-over type in which case the ranking of genotypes remain constant across environments and the interaction is significant, because of change in magnitude of response of varieties (Matus *et al.*, 1997). It may be a cross-over G x E interaction in which case a significant change in rank occurs from one environment to another. In the present investigations, the interaction is of cross-over-type as the ranking of varieties changed at every location (Matus *et al.*, 1997). Highly significant means among genotypes, revealing the presence of genotypic variability for grain yield. No significant interaction between genotypes and environments indicated that different genotypes response differently under multi-environmental conditions. Pooled deviation for traits showed that the tested genotypes differed considerably with respect to their response to environments (Table 2). The G x E was studied further using the regression analysis. A genotype is considered to be stable over different environments if it has higher performance, unit slope and deviation from regression (S^2d) near to zero (Akcura *et al*., 2005). The same was true in our results for AZRC-3, AZRC-2 and AZRC-1 genotypes by habiting comparatively higher mean grain yield, values near to unity and dispersion values near to zero. These genotypes were less responsive to environmental changes and considered to be widely adopted. The overall regression coefficient of genotype mean yield on the environmental index ranges from 0.998 in case of cultivar AZRC-3 to 1.004 in case of local wheat cultivar (Table 4). Cultivar AZRC-4 with greater regression coefficient (bi $\geq$1) and minimum values of S^2d (0.002) is found to be adapted to a specific environment. Cultivar AZRC-3, 2 and 1 were higher yielding with regression coefficient values close to unity (0.998) with dispersion value (S^2d = 0.002) and therefore were stable and widely adapted. Similar results have also been reported by *(*Lillimo *et al.*, 2004).

In breeding for wide adaptation, genotypes must have the genetic potential for superior performance under ideal growing conditions, and yet must also produce acceptable yields under less favorable environments (Koemel *et al.*, 2004). Favoring the cultivation of specially adapted germplasm is generally convenient for maximizing regional yields and increasing the biodiversity of cultivated material. The comparison of adaptation studies plays a key role in cultivar recommendation for a specific environment and of general cultivation in different climatic conditions. It can be concluded that cultivars AZRC-3, AZRC-2 and AZRC-1 were stable and widely adapted for grain yield. Cultivars AZRC-1 (AZRI-96), AZRC-3 (Tijaban-10) and AZRC-4 (Sariab-92) have already been released as commercial varieties for general cultivation in rainfed areas of Balochistan, Pakistan.

Table 1. Codes and parentage of five tested wheat genotypes.

Genotype	Parentage
AZRC-1 (AZRI-96)	MEN’SIB/MY48//4/14/3/ YAYLA 305
AZRC-2 (K-98)	DMN//SUT/AG(ES86-7) /3/OPAT/4/T71A1039 / VI*3/ AM1
AZRC-3 (Tijaban-10)	W3981A/JUP
AZRC-4 (Sariab-92)	SRMA/TUI
Local White	Local White (Landrace)

Table 2. Combined analysis of variance for grain yield of five wheat genotypes planted at three locations.

Sources	d.f	S.S	M.S	F-Value
Total	14	102225.125	7301.79	
Environment	2	99329.422	49664.771	
Varieties	4	2895.125	723.781	9855.745
Var. x Env.	5	0.578	0.072	
Env. + Var. x Env.	10	99330.0	9933.00	
Env. (lin)	1	99329.273	99329.273	
Var. x Env. (lin)	4	0.359	0.090	1.223
Pooled Dev.	5	0.376	0.073	22.053
Pooled Error	28	0.093	0.003	

dF: Degree of freedom

Table 3. Mean grain yield (kg/ha) of five wheat genotypes at three location during 2006-07.

Genotype /Cultivar	Akhterzai (Qilla Saifullah)	Naliwalizai (Loralai)	Saddiqabad (Mastung)	Mean
AZRC-1	2613	1530	1787	1976
AZRC-2	2617	1630	1750	1999
AZRC-3	2973	1667	1970	2203
AZRC-4	2320	1430	1600	1783
Local White	1210	1142	1242	1198
Mean	2347	2266	1670	

Table 4. Stability parameter for grain yield (kg/ha) of five wheat genotypes grown over three locations.

Genotypes	Mean	Regression Coefficient (bi)	Dispersion S^2d
AZRC-1	1976	0.999	0.001
AZRC-2	1999	0.999	0.000
AZRC-3	2203	0.998	0.002
AZRC-4	1783	1.000	0.002
Local White	1198	1.004	0.003

REFERENCES

Ahmed, J., M.H. Choudhery, S. Salah-ud-Din and M.A. Ali (1996). Stability for grain yield in wheat. Pak. J. Bot., 28(1): 61-65.

Akcura, M., Y. Kaya and S. Taner (2005). Genotype-environment interaction and phenotypic stability analysis for grain yield of durum wheat in the Central Anatolian Region. Turk. J. Agri. 29(5): 369-375.

Alaei M., M. Zaefizadeh, A. Atamehr, M. Khayatnezhad and Z. Alaei (2011). Analysis of drought resistance sources from detection function and regression analysis in durum wheat. Adv. Environ. Biol., 5(1): 136- 140.

Annicchiarico, P. (2009). Coping with and exploiting genotype-by-environment interactions. Plant breeding and farmer participation Edited by Ceccarelli, S., E.P. Guimarães, E. Weltizien, Food and Agriculture Organization of the United Nations FAO. Rome, Italy. Pp. 519-564.

Anonymous (2010). Agricultural Statistics of Pakistan (2009-10). Ministry of Food, Agriculture & Livestock, Govt. of Pakistan (Economic Advisory Wing), Islamabad, Pp. 3-4.

Arain, A.G. and K.A. Siddiqui (1977). Stability parameters of wheat mutants. Env. and Exp. Bot., 17: 13-18.

Arain, M.A., M.A. Sial and M.A. Javed (2001). Stability analysis of wheat genotypes tested in multi-environmental trials METs) in Sindh Province. Pak. J. Bot., 33 (Special Issue): 761-765.

Ceccarelli, S., S. Grando and R.H. Booth (2006). International breeding programmes and resource-poor farmers: crop improvement in difficult environments. The International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. Pp. 189-199.

Clarke, J.M., I. Romagosa and R.M. Depauw (1991). Screening durum wheat germplasm for dry growing conditions. Morphological and physiological criteria. Crop Sci.,31(3): 770-775.

Eberhart, S.A and W.A. Russel (1966). Stability parameters for comparing varieties. Crop sci., 6(1): 36-40.

Erkul, A., A. Ünay and, C. Konak (2010). Inheritance of yield and yield components in a bread wheat (*Triticum aestivum* L.) Cross. Turk. J. F. Cr., 15(2): 137-14.

Eskandari, H and K. Kazemi (2010). Response of different bread wheat (*Triticum estivum* L.) genotypes to post-anthesis water deficit. Not. Sci. Bio., 2(4): 49-52.

Gauch, H.G., H.P. Piepho and P. Annicchiaricoc (2008). Statistical analysis of yield trials by AMMI and GGE. Further considerations. Crop Sci., 48(3): 866-889.

Hafiz M., M. Akram, I. Sarfraz, M. Saeed, A. Yar, A. Ali, K.A. Sahi and M.A. Nadeen (2004). Drought tolerance studies of wheat genotypes. Pak. J. Bio. Sci., 7(1): 90-92.

Hamam, K.A., A. Sabour and G.A. Khaled (2009). Stability of wheat genotypes under different environments and their evaluation under sowing dates and nitrogen fertilizer levels. Aust. J. Bas. and Appl. Sci., 3(1): 206-217.

Kusaksiz, T. and S. Dere (2010). A study on the determination of genotypic variation for Seed yield and its utilization through selection in durum wheat (*Triticum durum* Desf.) mutant populations. Turk. J. Fld Cr., 15(2): 188–192.

Khan, A.J., F. Azam, A. Ali, M. Tariq, M. Amin and T. Muhammad (2007). Wide and specific adaptation of bread wheat inbred lines for yield under rainfed conditions. Pak. J. Bot., 39(1): 67-71.

Koemel, J.E., Jr., A.C. Guenzi, B. F. Carver, M.E. Payton, G.H. Morgan and E.L. Smith (2004). Hybrids and pureline hard winter wheat yield and stability. Crop Sci., 44(1): 107-113.

Konooka I., M. Tanskam, A. Pszczolkowska., G. Fordonski., W. Kozirok., J. Olszewski (2007). The Effect of water stress on wheat kernel size, color and protein composition. Pol. J. Nat. Sci., 22(2): 157-171.

Lillimo, M., M. van Ginkel, R.M. Trethowan, E. Hernandez and S. Rajaram (2004). Associations among international CIMMYT bread wheat yield testing locations in high rainfall areas and their implications for wheat breeding. Crop Sci., 44(4): 1163-1169.

Ludlow M.M. and R.C. Muchow (1990). A critical evaluation of traits for improving crop yields in water limited environments. Adv. Agron., 43: 107-153.

Matus, A., A.E. Slinkard and C.V. Kessel (1997). Genotype x Environment interaction for carbon isotope discrimination in spring wheat. Crop Sci., 37(1): 97-102.

Moayedi A.A, A.N.. Boyce and S.S. Barakbah (2010). The performance of durum and bread wheat genotypes associated with yield and yield component under different water deficit conditions. Aust. J. Basic Appl. Sci., 4(1): 106-113.

Nachit, M.M., G. Nachit, H. Ketata, H.G. Jr. Gauch and R.W. Zobel (1992). Use of AMMI and linear regression models to analyse genotype-environment interaction in durum wheat. Theor. Appl. Gene., 83(5): 597-601.

Naghavi, A., O. Sofalian**,** A. Asghari, M. Sedghi (2010). Relation between freezing tolerance and seed storage proteins in winter bread wheat (*Triticum aestivum* L.). Turk. J. Fld. Cr., 15(2):154-158.

Peterson, C.J., J.M. Moffatt and J.R. Erickson (1997). Yield stability of hybrids vs. pureline hard winter wheats in regional performance trials. Crop Sci., 37(1): 116-120.

Quarrie S.A., J. Stojanovic and S. Pekic (1999). Improving drought resistance in small grain cereals: A case study, progress and prospects. Pl. Gr. Regul., 29: 1-21.

Sial, M. A., M.U. Dahot, S.M. Mangrio, B. Nisa Mangan, M.A. Arain, M.H. Naqvi and Shabana Memon (2007). Genotype x environment interaction for grain yield of wheat genotypes tested under water stress conditions. Sci. Int., 19(2): 133-137.

Trethowan R.M. and M. Reynolds (2007). Drought resistance. Gentic approaches for improving productivity under stress. In: H.R. Buck *et al*. (eds.): Wheat production in stressed environments. Springer Pub. The Netherlands, Pp. 289-299.

Wright G.C. and N.C. Rachaputi (2004). Drought and drought resistance. In Encyclopedia of plant and crop science. Ed. R.M. Goodman (Marcel Dekker, Inc.: New York), Pp. 386-390.

Yan, W. and I. Rajcan (2002). Biplot analysis of test sites and trait relations of Soybean in Ontario. Crop Sci., 42(1): 11-20.

Zubair, M. and A. Ghafoor (2001). Genotype Environment interaction in Mungbean. Pak. J. Bot., 33(2): 187-90.