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Characterization of bread wheat genotypes under drought stress at seedling stage

Hafiz Ghulam Muhu-Din Ahmed[*1], Muhammad Usman Manzoor[2], Muhammad Rizwan[1], Fahad Idrees[1], Amjad Saeed[3], Muqaddas Tanvir[4], Abdul Qadeer[2],

[1]*Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan*

[2]*Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan*

[3]*Punjab Forestry Research Institute, Faisalabad, Pakistan*

[4]*Department of Rural Sociology, Faculty of Social Sciences, University of Agriculture, Faisalabad, Pakistan*

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Abstract

Drought is a worldwide problem and present climatic changes have even made it is worse in many parts of the world. Exposing plants to water stress adversely affect plant growth and productivity. Twenty seven diverse wheat genotypes of bread wheat were evaluated for seedling trait sunder drought conditions. On the basis of mean values considerable variation was observed for all the characters. Comparison of mean performance under drought stress conditions indicated that the root related traits were the most sensitive traits, followed by shoot related traits. Wheat genotypes Chakwal-50 possessed maximum dry root weight, dry shoot weight and fresh shoot weight while had minimum shoot length. The genotype Ass-11 showed maximum fresh root weight while the genotype Pasban-90 had highest value for root length among studied genotypes. The superior genotypes Chakwal-50 followed by Ass-11 and Pasban-90 can be used to develop new promising and improved varieties for water stress conditions. These can be further exploited in further generations for more improves morphological characters conferring resistance to water stress conditions.

* **Corresponding Author:** Hafiz Ghulam Muhu-Din Ahmed ✉ ahmedbreeder@gmail.com

Introduction

Wheat (*Triticum aestivum* L.) is a member of family Phocaea and is the king of cereals in many countries of the world including Pakistan. The archeological records suggest that wheat was first found in the regions known as Fertile Crescent and Nile Delta (Lev-Yadun *et al*., 2000). It is staple food crop of 1/3rd world's community. It is one of the 1st cereal crop known to be domesticated for food. Wheat is used for making bread, flour, bakery products (cakes, cookies, and pretzels), semolina and breakfast cereals. It is important in regard to nutritive value, production, storage space qualities, utilization, adaptation and transaction (Hogg *et al*., 2004). Wheat is a rich and cheaper source of protein.

In Pakistan, wheat is cultivated as staple food and cash crop that's why Pakistan's economy conspicuously depends on this crop. Wheat is mainly grown on rainfed land, and about 37 % of the area of developing countries consists of semiarid environments in which available moisture constitutes a primary constraint on wheat production (Dhanda *et al.,* 2004). In South Asia, cultivation of wheat in central, northern and north western India, while in Pakistan it is adapted to the plain areas.

The situation of wheat production in Pakistan is much better than before but still consistent efforts are required to keep the pace with the ever increasing population. It is backbone of economy of Pakistan with share of 10.1 % value added in agriculture and contributes 2.2 % to gross domestic product (GDP) of Pakistan. Wheat production has increased from 23.5 million tons to 24.2 million tons showing an increase of 3.2 % but target was not achieved, there was 5 % decline in yield. (Pakistan Economic Survey, 2015-16).

Requirement of food is increasing day by day with the growing population. Demand of wheat is increasing with increasing population. So there is need to breed varieties with high production even in water stress conditions. Wheat breeders are trying to get maximum yield with limiting resources (Ahmed and Mustafa, 2017).

The effects of drought on yield of crops depend on their severity and the stage of plant growth during which they occur. Seed germination is the first stage of growth that is sensitive to water deficit. Water limitation is a big problem among all the major problems. It is a great challenge for a plant breeder to face different types of drought (Hong Bo *et al*., 2006).

Yield is a polygenic trait and influenced by environment. Yield can be increased by making uncultivated lands arable by modern cultivation practice or by improving our commercial varieties using germplasm resources and breeding practices (Ahmed *et al,* 2015a; Ahmed *et al,* 2017a). To evolve high yielding, drought resistant varieties better understanding of various morphological characters like seedling traits need special attention (Ahmed *et al,* 2015b; Ahmed *et al,* 2017b).

To overcome reduction in yield potential, the genetic material of varieties and genotypes have to be reshuffled so that these varieties and genotypes may attain an ideal genetic makeup which would help to give better performance in a range of changing environment. There are two ways to increase the production either to increase the land area or increasing yield per acre. Wheat is grown under a diverse range of areas and environmental conditions.

The varying nature of drought and the complexity of the genetic control of plant responses determine the difficulties in developing high yielding cultivars under water limited environments (Ahmed, 2017; Ahmed *et al* 2017c).

Therefore these problems should be eliminated. Breeders are doing their best to develop wheat cultivars with high yield as well as drought tolerance.

The objectives of present study were to evaluate varieties under water stress conditions and assess the morphological basis of water stress tolerance for different plant traits.

Materials and methods

Experimental site

The proposed study was carried out to assess the morphological traits in water stress conditions. The research was carried out in both glass house and field conditions. During the season 2016, 27 diverse wheat genotypes were screened for water stress tolerance.

The experiment for screening was conducted in glass house in the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad.

Design of experiment

Lay out of completely randomized design with two replications was used for this experiment. Seeds were sown in 9" × 4" polythene bags under water stress (Khan *et al,* 2013). Polythene bags were filled with sand. Nutrients were applied at first watering. Only one watering was applied to water stress environment after sowing. After six weeks data for these traits were taken like, shoot length, root length, fresh shoot weight, fresh root weight, dry shoot weight and dry root weight (Noorka *et al.,* 2012).

Data analysis

Data were subjected to analysis of variance technique (Steel *et al* 1997). Plant traits showing significant differences among genotypes were further analyzed.

Results and discussions

The experiment was conducted in glasshouse of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad to test the seedling traits of twenty seven genotypes under drought conditions. All the traits under study showed changes in mean value under water stress condition for most of the genotypes. Some findings have been reported by Khan *et al.* (2007) and Shabir *et al.* (2011). It appeared that variability under water stress condition decreases. Mean values for different traits i.e. shoot length, root length, fresh weight and dry weight decreases. Such type of information has also been reported by Dhanda *et al.* (2004). Only those genotypes resist in change of mean values for different traits under water stress conditions which are resistant to water stress.

Table 1. ANOVA for various seedling traits of wheat under drought conditions.

Sources of variation	DF	Shoot length	Root length	Fresh root weight	Fresh shoot weight	Dry root weight	Dry shoot weight
Genotypes	26	4.271	50.083	50.083	0.326	0.326	0.02
Error	54	0.406	0.603	0.603	0.001	0.001	0
Total	80	4.677	50.686	50.686	0.327	0.327	0.02

** Highly significant.

The table 1 Analysis of Variance (ANOVA) reveals that there were highly significant differences were recorded among genotypes for all the traits.

Shoot related traits

Selection against drought stress at seedling stage most frequently practiced. Seedling parameters proved good criteria of selection wheat genotypes for their tolerance against drought (Noorka *et al,* 2012).Shoot length and root length is an important seedling trait and is also affected by water stress. Phenotypic expression in any trait is result of environment and genotype interaction.

Data collected for shoot length for all genotypes varied significantly ranging from 10.87 cm (Chakwal-50) to 16.9 cm in water stress environment as shown in table 2. Fresh shoot weight is an important seedling trait and is also affected by water stress. By it we come to know how much biomass is gained by the seedling. Analysis of variance showed data collected for fresh weight is significant for all genotypes under water stress condition. Data varied significantly ranging from 0.34 g to 2.93 g (Chakwal-50) in water stress environment as shown in table 2.

Table 2. Mean values of wheat genotypes and their statistical significance under drought conditions.

Genotypes	Dry root weight	Dry shoot weight	Fresh root weight	Fresh shoot weight	Root length	Shoot length
units	(g)	(g)	(g)	(g)	(cm)	(cm)
Abadgar-93	0.3533^{HIJ}	0.1300^{JKL}	0.5300^{J}	0.4100^{M}	25.100^{LM}	12.600^{HIJK}
Anmol-91	0.3767^{HI}	0.1500^{IJ}	1.5400^{G}	2.2100^{EF}	26.900^{IJK}	12.167^{JK}
Chakwal-86	0.1233^{PQ}	0.0467^{M}	0.2400^{KL}	1.6767^{L}	27.167^{IJK}	12.200^{JK}
Uqab-2000	0.3233^{IJK}	0.1300^{JKL}	0.8267^{I}	1.8000^{JKL}	26.333^{K}	13.600^{EFG}
Bahawal-97	0.3300^{IJK}	0.1633^{HI}	0.8067^{I}	2.2367^{EF}	27.667^{HIJ}	12.267^{JK}
Bwp-2000	0.7733^{F}	0.2367^{EF}	2.0400^{DE}	2.4067^{DE}	31.600^{BC}	12.400^{IJK}
Bahtawar-94	1.0500^{B}	0.2733^{D}	3.7133^{B}	2.4467^{CD}	26.033^{KL}	13.367^{EFGH}
Bakhar-2002	0.9100^{C}	0.3000^{C}	4.8067^{A}	2.9333^{A}	23.267^{N}	14.733^{BC}
Bakhtawar-93	0.8200^{EF}	0.2833^{CD}	1.8133^{F}	2.8033^{AB}	23.233^{N}	13.300^{EFGHI}
BWL-0814	0.7700^{F}	0.2000^{G}	2.2700^{C}	2.7533^{AB}	23.233^{N}	14.633^{BCD}
Sonara-64	0.3333^{IJK}	0.1500^{IJ}	0.8133^{I}	2.1233^{FGH}	24.800^{M}	16.033^{A}
PBN-51	0.2367^{MN}	0.0700^{M}	0.3200^{KL}	1.7467^{KL}	27.833^{GHI}	13.067^{EFGHIJ}
C-586642	0.5333^{G}	0.2600^{DE}	2.2000^{CD}	2.6467^{BC}	32.200^{B}	13.067^{EFGHIJ}
Chakwal-50	1.2567^{A}	0.4100^{A}	3.7967^{B}	2.9300^{A}	32.700^{B}	10.867^{EHIJK}
Ass-11	0.8300^{DE}	0.3400^{B}	4.9333^{A}	2.8333^{AB}	26.600^{JK}	13.800^{DEF}
Watan01	0.1600^{P}	0.1633^{HI}	0.4167^{JK}	1.9500^{GHIJ}	29.900^{DE}	12.233^{JK}
AARI-2011	0.2633^{LMN}	0.1133^{L}	0.3000^{KL}	1.8267^{JKL}	20.633^{O}	11.700^{KL}
Pasban-90	0.4033^{H}	0.1833^{GH}	1.1667^{H}	2.2333^{EF}	35.900^{A}	12.900^{FGHIJ}
FD-85	0.5167^{G}	0.1933^{G}	1.1567^{H}	2.2000^{F}	29.033^{EF}	14.867^{B}
GA 2002	0.0700^{Q}	0.1400^{IJ}K	0.2067^{L}	1.9067^{IJK}	28.633^{FGH}	12.733^{GHIJ}
Glaxy-2013	0.1667^{OP}	0.1600^{HI}	0.2533^{KL}	2.1467^{FG}	24.833^{M}	14.933^{B}
Gomal-2008	0.9233^{C}	0.1333^{JK}L	1.1633^{H}	2.0667^{FGHI}	28.933^{EFG}	13.900^{CDE}
Hashim-2008	0.3033^{JKL}	0.1433^{IJ}K	0.4067^{JK}	2.0433^{FGHI}	24.767^{M}	16.900^{A}
Inq-91	0.8767^{CD}	0.2267^{F}	2.2467^{C}	2.2133^{EF}	28.700^{FGH}	12.900^{FGHIJ}
Iqbal-2000	0.1500^{P}	0.1200^{KL}	0.2433^{KL}	1.8767^{IJKL}	29.667^{DEF}	13.767^{DEF}
Kaghan-93	0.2867^{KLM}	0.1500^{IJ}	0.5233^{J}	1.9333^{HIJK}	30.800^{CD}	12.800^{GHIJ}
Khyber-87	0.2200^{NO}	0.1533^{IJ}	1.9300^{EF}	0.3367^{M}	15.333^{P}	13.733^{DEF}

Data collected for dry shoot weight for all genotypes varied significantly ranging from 0.07 g to 0.41 g (Chakwal-50) in water stress environment as mentioned in table 2.

The genotypes sharing common alphabets were not significant from each other but significant from other genotypes as shown in table 2.Shoot is made of series of phytomers an elongated internodes and the bud in the axil of the leaf.

There are 6-16 phytomer units which for the shoot. Basal internodes are small and peduncle internodes are large (Jaleel *et al,* 2009; Khan *et al,* 2013).

Shoot act as best source of sink for plant therefore it is very critical attribute for plant during water deficit stress.

Shoot length is most drought affected parameter and decrease significantly with increasing water shortage (Khan *et al,* 2002). These results were in corroboration with (Jaleel *et al,* 2009; Khan *et al,* 2013).

Root related traits

In order to identify the wheat genotypes desirable for breeding program for development of water deficit tolerance and high yielding cultivars, root length is distinguish and appropriate trait for choice. Wheat plant has two types of root systems. Seminal root system starts right after germination.

After germination adventurous roots that appear from the basal nodes. When seed germinates root bursts through coleorhizae and followed be emergence of 4-5 lateral seminal roots. Water shortage always affects plant in a way that it have to adjust its morphological, physiological and biochemical pathways by varying, switching on or switching off the gene expression as a comeback mechanism (Noorka *et al,* 2007; Rauf *et al,*2007). Data collected for root length for all genotypes varied significantly ranging from 15.33 cm to 35.90cm(Pasban-90) in water stress environment as shown in table2. Data collected for fresh root weight for all genotypes varied significantly ranging from 0.21 g to 4.93g (Ass-11) in water stress environment as presented in table 2.

These results are similar to the findings of Data collected for dry root weight for all genotypes varied significantly ranging from 0.07 g to 1.26 g (Chakwal-50) in water stress environment as displayed in table 2. Root length is very imperative attribute for choice of drought resistant genotypes (Khan *et al.* (2002).

Genetic unevenness among root length is the tool to develop drought resistant wheat cultivars. Lines which have maximum root length executed better in drought environment (Noorka *et al,* 2007).

Pour-Aboughadareh *et al,* (2017) concluded wheat lines maintained higher root length proved to be water deficit tolerant. During investigation genotypes showed optimum root length performed better in water shortage conditions. Zeng *et al,* (2016)found during his studies the only survivor wheat cultivar during water shortage had produced deeper roots.

During water shortage circumstances those plant which have capability to grow longer and deeper roots can survive well (Noorka *et al,* 2014). Therefore the performance of genotypes which indicated longer root length also performed fine in water deficit conditions.

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