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ACCESSING POTENTIAL OF SEEDLING TRAITS FOR SCREENING OF WHEAT GENOTYPES UNDER DROUGHT CONDITIONS

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ABSTRACT

Drought stress causes considerable decrease in wheat yield especially in developing countries like Pakistan. In current study, seedling traits i.e., root length, shoot length, shoot fresh weight, shoot dry weight and root to shoot (length) ratio were selected to find their effectiveness in evaluating drought tolerance of wheat genotypes. It was found that different genotypes showed different response under normal and drought conditions as mean squares for genotypes were significant. When plant is exposed to stress, it tries to overcome the stress by adopting different strategies like extending root system to reach the deep soil water. Increase in stress causes reduction in both root and shoot length. Genotypes named Faisalabad-08, Sehar-06, 9633, 9507 and lasani-08 showed maximum and high root length under normal conditions but their root length decreased drastically when exposed to drought environment. Because of their behavior they are tagged as drought susceptible genotypes. Genotypes Chakwal-86, Ass-11, Manthar-2003, Miraj 2008, Chakwal-50, 9488, 9805, 9859, 9512 and 9637 showed high values for root length under drought condition and while comparing their performance under both the environments i.e., normal and drought, their root length decreased non-significantly. So, these genotypes are tagged as drought tolerant genotypes.

Keywords: Drought, Stress, Seedling traits, Wheat

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1. INTRODUCTION

Many biotic and abiotic stresses resentfully affect the crop yield (Farooq et al. 2011) and most prominent is drought which causes considerable decrease in wheat yield (Lambers et al. 2008; Datta et al. 2011; Saint Pierre et al. 2012; Noorka and Heslop-Harrisan 2013) by reducing the production of crop (Aroca 2012). Drought causes misbalancing of nutrients and reduces efficiency of water usage (Rasool 2008; Li et al. 2009; Farooq et al. 2010; Ahmad et al. 2017) and results in the synthesis and accumulation of ABA (Abscisic acid). World population is increasing and 9 billion is expected until 2050 (FAO 2014) and expected demand for the world to feed will rise up to 40% by 2030 (Dixon et al. 2009). It's the need of time to find a suitable and economical solution which is to evaluate the available genetic variability in the wheat crop (Ahmed et al. 2020; Khadka et al. 2020a; Khadka et al. 2020b). Aim of the current study is to find genotypes that are tolerant to water deficit and have little effect of stress.

To estimate the expected yield of wheat, vigorous seedling is of great importance (Chowdhry et al. 1999; Misra et al. 2002; Noorka and Khaliq, 2007). Water deficit is a limiting factor that reduces germination (Misra 1990; Misra et al. 2002; Nezhadahmadi et al. 2013; Sallam et al. 2019). At early stage of development, root length, shoot length along with root shoot ratio have great importance for the evaluating the performance of genotypes under water deficit condition (Dhanda et al. 2004; Shahbazi et al. 2012; Wadzingeni et al. 2016). Different cultivars have different response towards water deficit (Aziz et al. 2011). Strategy to improve crop production under water deficit is to find genotypes that show good performance under these conditions (Rashidi and Seyfi 2007; Rajaram 2001; Waqas et al. 2013).

At early stages of seedling, the effective method for the selection is based upon seedling traits that offers reduction in labor and drop in expenses. In the current study, 150 wheat genotypes will be selected to evaluate their performance under normal and drought conditions at seedling and the relationship among the seedling traits.

2. MATERIALS AND METHODS

Germplasm of 150 *Triticum aestivum* genotypes was compiled from Regional Agricultural Research Institute (RARI) Bahawalpur, CIMMYT and University of Agriculture Faisalabad. These wheat genotypes were evaluated in two different environmental settings i.e., under normal and drought stressed condition in the controlled wire house of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad (Pakistan), using

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Complete Randomized Design (CRD) with three replications during the crop season 2014-2015. The polythene bags (18×9cm) were used in which seed were sown packed with sandy loam soil (pH 7.8 and E.C 1.7dSm-1). For each set of experiment, fifteen plants/genotype/replication were grown. After germination one seedling/one polythene bag was allowed. Plants under controlled condition (normal) were watered to preserve soil-water contents to the level of field capacity. In the stress (drought) experiment the irrigation was prohibited immediately after germination. Plants were harvested at three leave stage and cleaned carefully to remove soil from the seedlings and plants were kept in Kraft paper bags.

Data collection was maintained at standard level of proficiency for seedling traits i.e., root length, shoot length, shoot fresh weight, shoot dry weight and root to shoot (length) ratio. Compiled data was imperiled to analysis of variance (Steel et al. 1997) and simple correlation coefficients (Pearson 1920) were considered between the seedling traits and their significance was verified.

3. RESULTS AND DISCUSSION

Analysis of variance was applied on the obtained data and different sources of variances behaved differently. According to the analysis, genotypes were significantly different from each other at 1% significant level as square of means were highly significant.

Under the normal conditions i.e., control, all the genotypes behaved differently from each other. For root length, mean value obtained was 13.58cm with highest values recorded were 19.98, 19.24, 18.46, 18.04, 17.99 for Faisalabad-2008, lasani-08, sehar-06, Miraj 2008 ad 9507, respectively. While lowest values attained by 9438, 9193, GA-02 were 9.35, 9.5 and 10.05, respectively (Fig. 1a; 1b). Under drought stress, root length ranged from lowest ufaq-02 (5.251cm) to highest Chakwal-86 (17.87 cm). Under normal condition shoot length ranged between 17.101 to 33.502 for AS-02 and Faisalabad-08, respectively while genotypes showed different performance by decreasing under drought stress and ranged 11.161 cm to 30.256cm for lasani-08 and Chakwal-86, respectively (Fig. 2a; 2b).

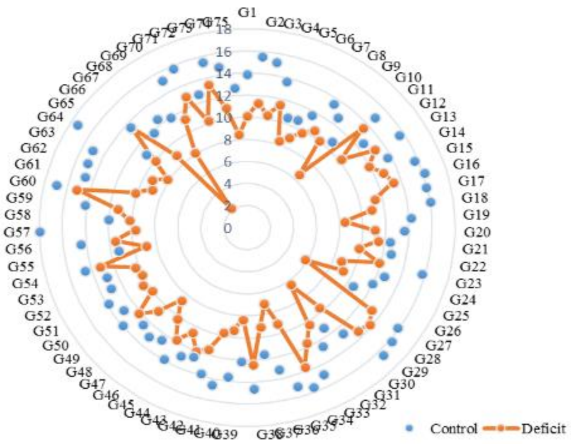

Fig. 1a: Root length of wheat genotypes 1-75.

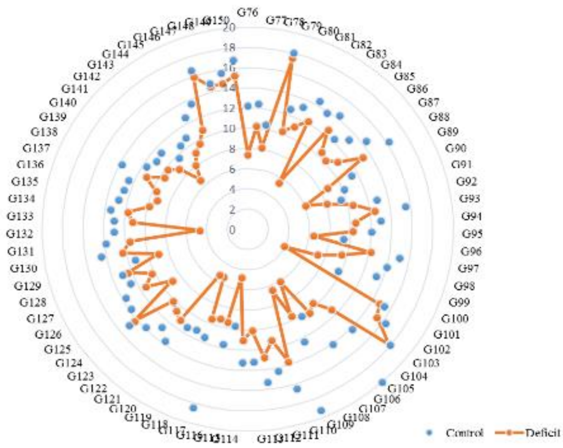

Fig. 1b: Root length of wheat genotypes 76-150.

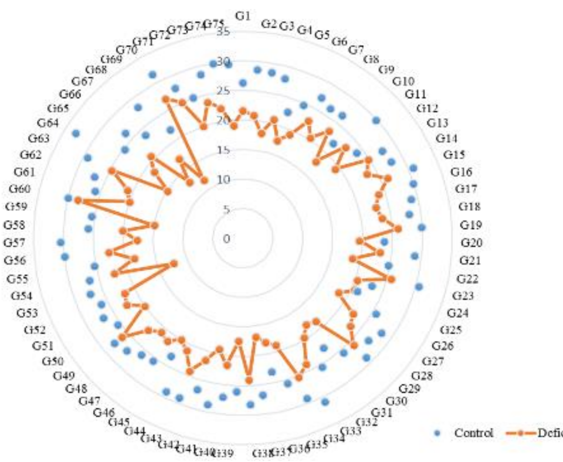

Fig. 2a: Shoot length of wheat genotypes 1-75.

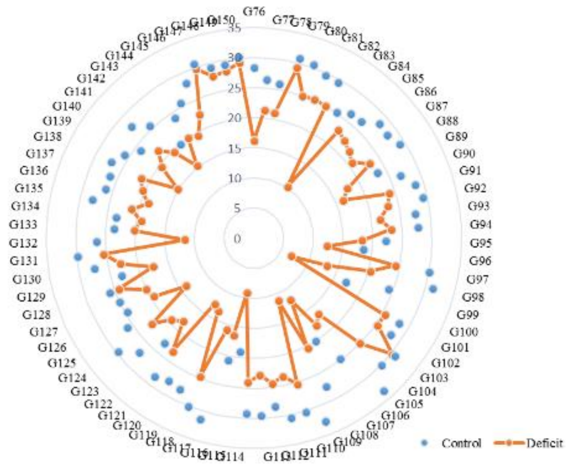

Fig. 2b: Shoot length of wheat genotypes 76-150.

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Table 1: Mean squares for 150 wheat genotypes sown under normal and stress (drought) conditions for various seedling traits

Characters	Genotype (df=149)	Environment (df=1)	G×E (df=149)	Error (df=600)
Root length	25.87522**	2426.272**	6.8251**	1.6736
Shoot length	62.1618**	8990.681**	18.6486**	2.780439
Shoot fresh weight	0.028653**	3.3218**	0.007092**	0.000049
Shoot dry weight	0.00665**	0.08726**	0.000282**	0.0000421
Root shoot ratio	0.02179**	0.000373^{NS}	0.007242^{NS}	0.004962

**highly significant, * significant, ^{NS} non-significant.

Genotype 9507 showed maximum fresh shoot weight (0.473g) followed by faislabad-08 (0.473g) and 9633 (0.466g) and minimum fresh weight as obtained by AS-02 (0.132g) under normal conditions but under drought conditions maximum and minimum shoot fresh weight of 0.39g and 0.056g was obtained by genotypes 9859 and AS-02, respectively (Fig. 3a; Fig. 1b). Similarly, to shoot fresh weight, in case of shoot dry weight under normal condition, genotype 9507 and Faisalabad-08 gained the maximum weight of both 0.069, followed by 9633 (0.066g), sehar-06 (0.066g) and lasani-08 (0.062g). Shoot dry weight under drought condition decreased significantly and ranged 0.045 to 0.003g for genotypes 9859 and AS-02, respectively (Fig. 4a; Fig. 4b). Under both the sowing conditions, genotypes showed different results for all the traits i.e., showed decreased performance under drought condition as compared to normal and percentage decrease was 23.64% for root length, 23.14% for shoot length, 38.96% for shoot dry weight and 51.08% for shoot dry weight (Fig. 5).

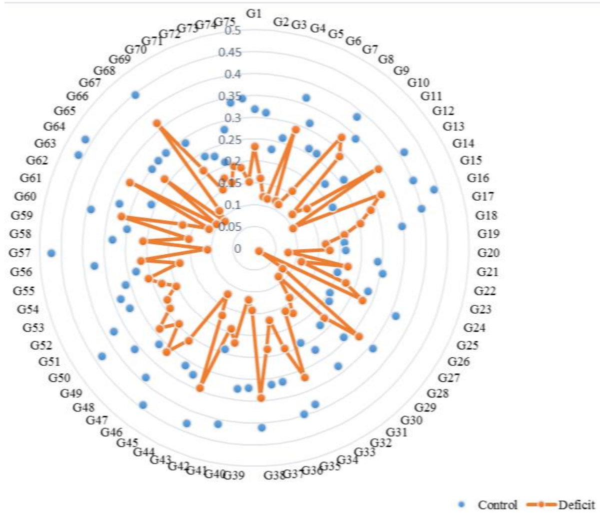

Fig. 3a: Fresh shoot weight of wheat genotypes 1-75

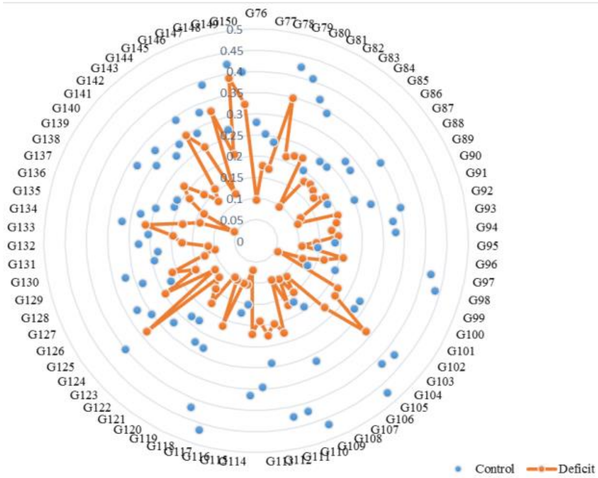

Fig. 3b: Fresh shoot weight of wheat genotypes 76-150

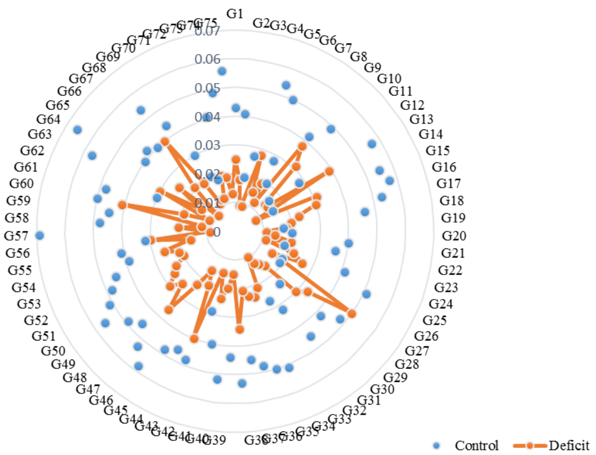

Fig. 4a: Dry shoot weight of wheat genotypes 1-75

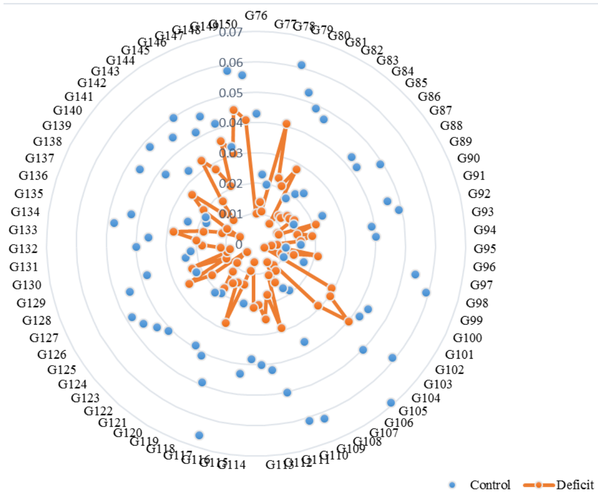

Fig. 4b: Dry shoot weight of wheat genotypes 76-150

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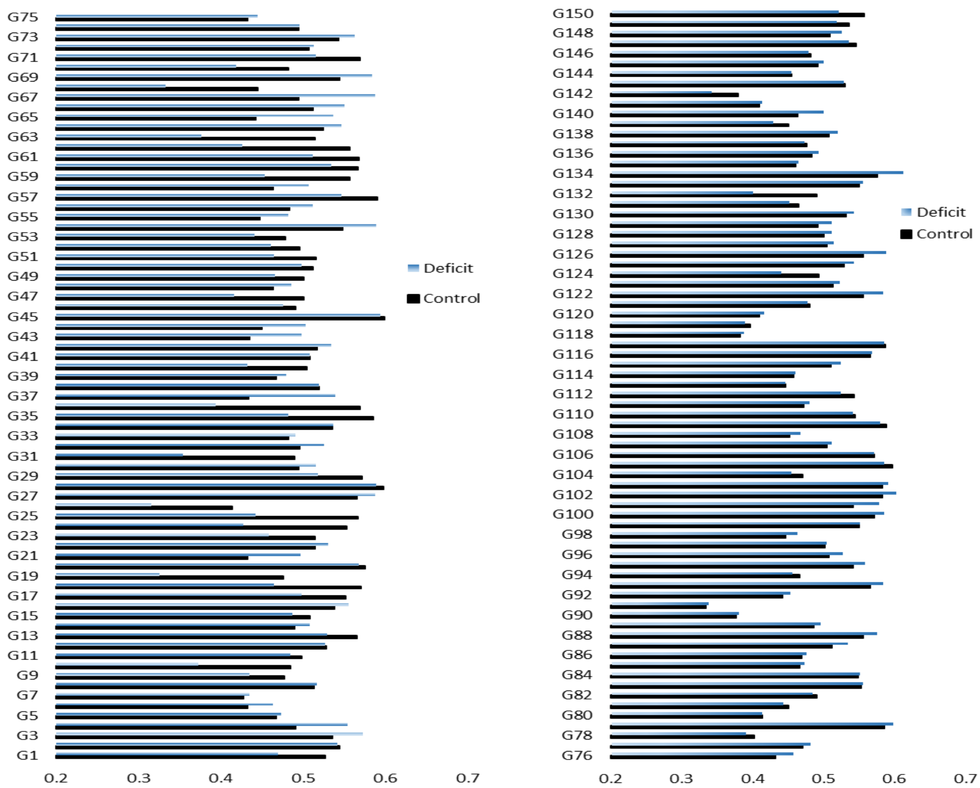

Fig 5: Left=Root shoot ratio under normal condition; Right=Root shoot ratio under drought condition.

Correlation analysis was also applied on the data to access the kind and extent of association among the seedling traits. Under normal sowing condition, length, fresh and dry weight of shoot and root shoot ration exhibited constructive and highly significant correlation coefficient. Length of shoot was positive and highly significant with shoot's fresh weight and shoot's dry weight while had destructive correlation with root shoot ratio. Relationship between fresh and shoot weight was positive and highly significant but only positive with root shoot ratio. Root shoot ratio and shoot dry weight were positive and non-significantly correlated with each other.

Table 2: Correlation coefficients among seedling traits for fifty wheat genotypes under non-stress (normal) condition

Characters	Root length	Shoot length	Shoot fresh weight	Shoot dry weight
Shoot length	0.695**			
Shoot fresh weight	0.466**	0.538**		
Shoot dry weight	0.366**	0.387**	0.893**	
Root shoot ratio	0.651**	-0.089NS	0.069NS	0.087NS

**highly significant, * significant, NS non-significant

Table 3: Correlation coefficients among seedling traits for fifty wheat genotypes under stress (drought) condition

Characters	Root length	Shoot length	Shoot fresh weight	Shoot dry weight
Shoot length	0.801**			
Shoot fresh weight	0.445**	0.533**		
Shoot dry weight	0.423**	0.517**	0.782**	
Root shoot ratio	0.477**	-0.87NS	0.029NS	0.029NS

**highly significant, * significant, NS non-significant

Similar type of association amid the seedling traits was found under drought (stress) conditions. Root's length was high positive significant correlation with shoot's length, fresh and dry weight of shoot and root soot ratio. Similarly, shoot's length was positive and significantly correlated with fresh and dry shoot's weight but showed negative non-significant correlation with root to shoot ratio. Fresh weight's correlation with shoot dry weight was positive and highly significant but negatively non-significant. Shoot dry weight and root shoot ratio had negative and non-significant correlation among them.

Many biotic and abiotic stresses resentfully affect the crop yield and most prominent is drought which causes considerable decrease in wheat yield by reducing the production of crop. Drought causes misbalancing of nutrients and reduces efficiency of water usage and results in the synthesis and accumulation of ABA (Abscisic acid). Keeping in mind the factors of increasing world population and diminishing water resources, it is necessity of time to find a better way to conserve water on one hand and feed people by maintaining wheat yield on the other hand. In current study, seedling traits selected in different genotypes were showed different response under normal and drought conditions as mean squares for genotypes were significant. These results are in support with those results found by Singh et al. (2008), Bayoumi et al. (2008), Ahmad et al. (2013) and Baloch et al. (2012). When plant is exposed to stress, it tries to overcome the stress by adopting different strategies like extending root system to reach the deep soil water (Khan et al. 2004). Increase in stress causes reduction in both root and shoot length (Agnihotri et al. 2007; Kaydam and Yagmur 2008; Ahmad et al. 2013; Rosero et al. 2020). This reduction may be because of some hormonal imbalance or reduced division of cells in root and shoot (Sharp and Davis, 1985; Misra 1990; Raziuddin et al. 2010; Khakwani et al. 2011; Khadka et al. 2020a). Trait that is compulsory for the survival under drought is the growth of roots (Misra 1990; Dhanda et al. 2004; Wadzingeni et al. 2016; Sallam et al. 2019). Genotypes named Faisalabad-08, Sehar-06, 9633, 9507 and lasani-08 showed maximum and high root length under normal conditions but their root length decreased drastically when exposed to drought environment. Because of their behavior they are tagged as drought susceptible genotypes. Genotypes Chakwal-86, Ass-11, Manthar-2003, Miraj 2008, Chakwal-50, 9488, 9805, 9859, 9512 and 9637 showed high values for root length under drought condition and while comparing their performance under both the environments i.e. normal and drought, their root length decreased non-significantly. So these genotypes are tagged as drought tolerant genotypes. It is recommended to conduct further research on the basis of above discussed study so that this evaluated germplasm could be utilized in creation of new germplasm. Crossing drought tolerant with susceptible e.g., in line x tester fashion will generate more variation and chances of hunting such strains that can withhold drought stress.

Conclusion: Above discussed results clearly mentioned the importance of seeding traits in determining the drought tolerance ability of wheat genotypes. Selection through seedling traits provided efficient and cost-effective selection method and saves a lot of resources, Further, breeding material evaluated in current study could be utilized in future breeding programs for development of drought tolerant wheat genotypes.

Author's Contribution: Research project was conducted by MOF whereas MK supervised and coordinated the research project.

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