Research Article

Radar Analysis of Spring Wheat Genotypes at Seedling Stage Against Limited Water Conditions

Hafiz Ghulam Muhu-Din Ahmed[1], Aziz Ullah[2], Muhammad Asim Bhutta[3*], Amna Bibi[3], Hafeez-ur-Rehman[4] and Umar Farooq[4]

[1]*Department of Plant Breeding and Genetics, Faculty of Agriculture and Environment, The Islamia University of Bahawalpur, Pakistan;* [2]*Department of Plant Breeding and Genetics, University of Sargodha, Pakistan;* [3]*Cotton Research Institute Multan, Pakistan;* [4]*Cotton Research Station Sahiwal, Pakistan.*

Abstract | Drought is globally a severe issue overall and current environmental changes have even exacerbated it in the numerous areas of the world. Adverse effects were observed on plant growth and productivity under drought conditions. Total 40 wheat genotypes with diverse genetic makeup were assessed in glasshouse for seedling attributes against limited water conditions using completely randomized design during the season 2019-20 in the Islamia University of Bahawalpur. Based on mean values reasonable variations were noticed in evaluated genotypes for studied attributes. Results from radar analysis, performance designated that the root related attributes were the most sensitive and important attribute followed by shoot related attributes. Chakwal-50 wheat variety had highest dry root weight (1.256g), dry shoot weight (0.41g) and fresh shoot weight (2.83g), while had minimum shoot length (10.87cm). The genotype Ass-11 possessed highest fresh root weight (4.93g) while the genotype Pasban-90 shown maximum value for root length (35.9cm) among other varieties. The out-performing varieties Chakwal-50 followed by Ass-11 and Pasban-90 can be utilized to create new promising genotypes against limited water conditions. These genotypes would be additionally used in next generations for improved morphological indices conferring drought-tolerant genotypes.

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***Correspondence** | Muhammad Asim Bhutta, Cotton Research Institute Multan, Pakistan; **Email:** bhuttabreeder@gmail.com
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Introduction

Wheat belongs to the Poaceae family and it is the king of cereals in many countries including Pakistan. Archaeological records suggest that wheat was first found in a time known as the Fertile Crescent and Nile Delta. (Lev-Yadun *et al*., 2000; Ahmed *et al*., 2020b). It is the staple food crop of 1 / third of the world's population. It is one of the earliest cereal crops known to be used for food. It is also utilized for making bread, flour, pastry kitchen items (cakes, treats, and pretzels), semolina and breakfast cereals. It is significant concerning nutritive worth, usage, transformation and exchange (Hogg *et al*., 2004). Wheat is a cheaper and rich source of protein. In Pakistan, wheat is grown as a staple food and as an economic crop, which is why the Pakistani economy obviously depends on it. Wheat is chiefly cultivated in rainfed area, and around 37 % of the territory of agricultural developing nations comprises of semiarid conditions which is a main problem of wheat yield (Dhanda *et al*., 2004). In South Asia, wheat development in central, northern and northwestern India, while in Pakistan it is mainly adapted to lowland (plain) areas. The circumstance of wheat yield in Pakistan is far superior to before yet at the same time steady endeavors are needed to keep the speed with the steadily expanding populace. It accounts for 9.2 percent of the value added in agriculture and 1.8 percent of the GDP. Self-sufficiency in wheat has been a core objective of every government. During 2020-21, area under cultivation increased by 4.2 percent to 9,178 thousand hectares over last year's sown area of 8,805 thousand hectares. Wheat crop recorded historic high production of 27.293 million tonnes showing an increase of 8.1 percent over 25.248 million tonnes production of last year (Economic Survey of Pakistan, 2020-21). Prerequisite of food is expanding time to time with the developing population. Need of wheat is also expanding with expanding population. So, there is necessary to create drought tolerant and high yielding wheat genotypes. Wheat breeders are attempting to obtain greatest yield under water deficit conditions (Ahmed *et al*., 2019). The impacts of dry season on wheat yield rely upon their seriousness and the phase of plant development during which they happen. Seed germination is the primary phase of development that is delicate to water deficiency. Water deficient is a major issue among every one of the serious issues. It is an incredible test for a plant breeder to confront various kinds of dry seasons (Mahmood *et al*., 2020). Yield is a quantitative character and impacted by climate. Yield can be expanded by making crude grounds arable by present day development practice or by improving our business assortments utilizing germplasm assets and reproducing rehearses (Surbhaiyya *et al*., 2020). To develop high yielding, dry season safe assortments better comprehension of different morphological characters like seedling characteristics need extraordinary consideration (Ahmed *et al*., 2020a; Zahra *et al*., 2021). To overcome decrease in yield potential, the genetic makeup of genotypes must be re-shuffled with the goal that these genotypes may achieve an ideal genetic makeup which would assist with giving better yield in a scope of evolving climate changes. There are two different ways to build the creation either to expand the land region or expanding yield per section of land. Wheat is developed under a different range of territories and ecological conditions. The changing phenomena of dry season and the complexity of genetic control of plant reactions determined the troubles in developing drought tolerant and high yielding wheat genotypes (Khan *et al*., 2018; Suliman *et al*., 2021). Subsequently these issues ought to be dispensed. Breeders are giving a valiant effort to create wheat varieties with high yield just as dry spell resilience. Today there are several graphs available for the researcher. A radar plot, invented by Georg von Mayr in 1877 can be viewed as a connected line graph, thereby reducing the size of the plot (Friendly and Denis, 2001). Radar is a statistical analysis and used for the graphical presentation of data of multiple traits in a single graph. A *radar chart* is a graphical method of displaying multivariate data in the form of a two-dimensional chart of three or more quantitative variables. RADAR-graph were developed from mean value using Excel-Stat in which display mean values relative to a center point for examined traits (Ahmed *et al*., 2020b). In this graph different axes emerging from a common central point. In most of the cases, all the axes are equally distributed and uniformly drawn from each other. Sometimes, the axes are also connected to each other to form different grids that make it easier for us to plot the spider chart. The circular form makes it easy to compare different entities, especially if there is an agreed sequence of the variable, and, as we have done, included a reference line. It has been found useful in plant sciences and health sciences to illustrate development or differences among the studied attributes (Friendly and Denis, 2001; Laino *et al*., 2015; Mamen *et al*., 2020). Radar charts are considered as a better alternative to column charts as they can depict multiple variables easily without creating a clutter, it is pretty easy to understand as it has a few basic elements such as element 1 (*Center point*) this is the core of a spider chart (at the center) from which different axes are drawn. Element 2 (*Axis*) each axis represents a variable in a radar chart and is given a name and different values. A radar graph has at least 3 axes. Element 3 *(Grids)*when axes are linked in a spider chart, it divides the entire graph into different grids that help us represent information in a better way. Element 4 *(Values)*once the graph is drawn, we represent various values on each axis and plot the chart for every entry by allocating distinctive colors (Ahmed *et al*., 2020b; Mamen *et al*., 2020). The objectives of present investigation were to assess genotypes under limited water conditions and to evaluate the morphological basis for water stress tolerance for diverse plant attributes.

Materials and Methods

Experimental location

The experiment for screening was conducted in wire-house during the season 2019-20 in the Islamia University of Bahawalpur.

Plant materials

In this experiment, diverse 40 wheat genotypes (Table 2) were screened for water stress tolerance.

Experimental design

Experiment was designed with completely randomized with two replicates under water stress conditions. Seeds were sown in 9" × 4" polythene bags (Khan *et al*., 2011) which filled with sand. Nutrients were applied at first watering. Only one irrigation was applied to the experiment after planting.

Data observation

After six weeks data for these traits were taken such as, shoot length (SL), root length (RL) fresh shoot weight (FSW), fresh root weight (FRW), dry shoot weight (DSW) and dry roost weight (DRW) (Noorka, 2014).

Statistical analysis

Data were exposed to analysis of variances (Steel, 1997) using the GenStat version 17, VSN, International (Payne *et al*., 2008). Plant characters exhibiting significant differences among genotypes were further examined for mean variability. The RADAR-graphs were created through *Excel Stat* (Ahmed *et al*., 2020b) which displays values relative to a central point for plots of observed traits under water limited environments.

Results and Discussion

This study was performed to observe the seedling characters of 40 genotypes under limited water stress. All characteristics under examination showed changes in mean values among all under the study genotypes. Previously observations have been stated by (Khan *et al*., 2011; Shabbir *et al*., 2012; Ahmed *et al*., 2020b) that mean values in limited water stress environments declined. Averaged values for studied attributes *i.e*. shoot lengths, roots lengths, fresh weights and dry weights decreased in present study. Similar results also recorded by (Dhanda *et al*., 2004). Just these genotypes oppose in difference in mean values for various attributes in water deficient conditions which are considered as drought tolerant. The Table 1 the results of Analyses of Variances (ANOVA) showed that there were high significant differences were found among genotypes for studied attributes. Radar is a statistical analysis and used for the graphical presentation of data of multiple traits in a single graph which used in this study In RADAR graph (Figure 1, 2 and 3) the mean value of seedlings traits was exhibited and indicate the variability of average values among all studied genotypes. Same observations were found by (Khan *et al*., 2018; Ahmed *et al*., 2020b) in wheat crop for limited water conditions. Such genotypes resist variation in the performance of the examined traits in limited water conditions considered to be drought tolerant genotypes.

Table 1: *ANOVA for various seedling traits of wheat under limited water conditions.*

Sources of variation	Genotype	Error	Total
	39 (df)	80 (df)	119 (df)
Shoot length(cm)	4.271**	0.406	4.677
Root length(cm)	51.090**	0.604	51.691
Fresh root weight (g)	50.083**	0.603	50.686
Fresh shoots weight (g)	0.328**	0.001	0.329
Dry roots weight (g)	0.326**	0.001	0.327
Dry shoots weight (g)	0.02**	00.01	0.03

*** Highly significant (0.01); * significant (0.05).*

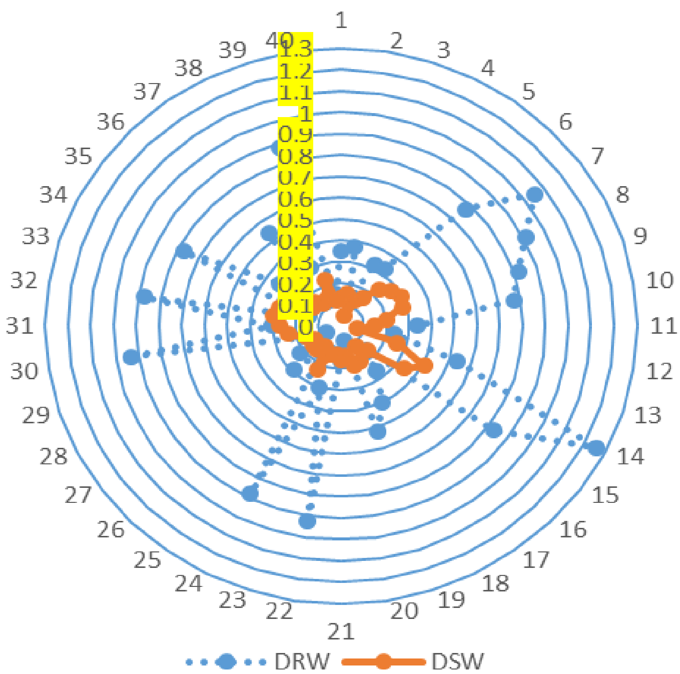

Figure 1: *RADAR analysis showing the performance of 40 spring wheat genotypes at seedling stage for dry root weight (DRW) and dry shoot weight (DSW) against limited water condition.*

Shoot related traits

Selection against drought stress at seedling stage most frequently practiced. Seedling parameters proved

Links Researchers

Table 2: *Names of studied genotypes under limited water conditions.*

Sr. No.	Genotype	Sr. No.	Genotype	Sr. No.	Genotype	Sr. No.	Genotype
G1	Abadgar-93	G11	Sonara-64	G21	Glaxy-2013	G31	PBW 222
G2	Anmol-91	G12	PBN-51	G22	Gomal-2008	G32	HD 2307
G3	Chakwal-86	G13	C-586642	G23	Hashim-2008	G33	DPW-621-50
G4	Uqab-2000	G14	Chakwal-50	G24	Inq-91	G34	PBW 343
G5	Bahawal-97	G15	Ass-11	G25	Iqbal-2000	G35	HD 2967
G6	Bwp-2000	G16	Watan01	G26	Kaghan-93	G36	BWL-1793
G7	Bakhtawar-94	G17	AARI-2011	G27	Khyber-87	G37	BWL-9022
G8	Bakhar-2002	G18	Pasban-90	G28	BWL-812	G38	BWL-0924
G9	Bakhtawar-93	G19	FD-85	G29	PBW-175	G39	C-78711
G10	BWL-0814	G20	GA 2002	G30	Anza	G40	C-252782

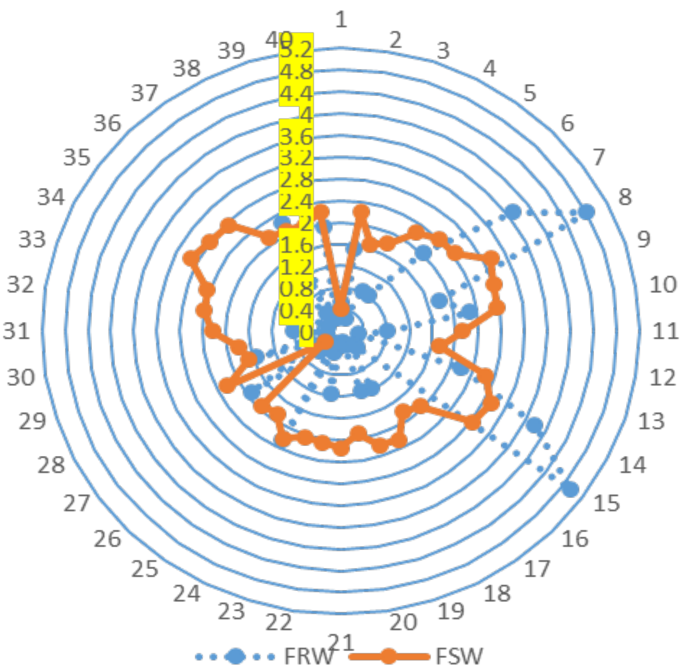

Figure 2: *RADAR analysis showing the performance of 40 spring wheat genotypes at seedling stage for fresh root weight (FRW) and fresh shoot weight (FSW) against limited water condition.*

good criteria of selection wheat genotypes for their tolerance against drought (Noorka *et al*., 2013). Shoot length and roots length is a significant seedlings attribute and is additionally influenced by water deficient. Phenotypically articulation in any character is the aftereffect of climate and association. Information noted for shoot length for all genotypes changed fundamentally from 10.87 cm (Chakwal-50) to 16.9 cm in drought conditions as shown in Table 3. Fresh shoots weights significant seedlings attributes and is likewise influenced by drought conditions. By it we know to realize how biomass is acquired by the seedlings. In this study results showed that results for this trait was significant for all genotypes under water deficient condition. Mean values ranged from 0.34 g to 2.93 g (Chakwal-50) in drought conditions as shown in Tables 2 and 3. Data recorded for studied genotypes for dry shoots weights attribute ranged from 0.07 g to 0.41 g (Chakwal-50) in drought conditions as mentioned in Table 3. Shoot is made of series of phytomeres an elongated internode and the bud in the axil of the leaf. There are 6-16 phytomere units which for the shoot. Basal internodes are small and peduncle internodes are large (Jaleel *et al*., 2009; Khan *et al*., 2011; Haque *et al*., 2021). Shoots acts as the best source of sink for plants, so it is very critical indices for plants during water stress. The length of the shoot is the parameter most affected by drought and decreases significantly with an increasing water scarcity. Olumekun*et al*. (2020) results were in corroboration with (Jaleel *et al*., 2009; Othmani *et al*., 2021).

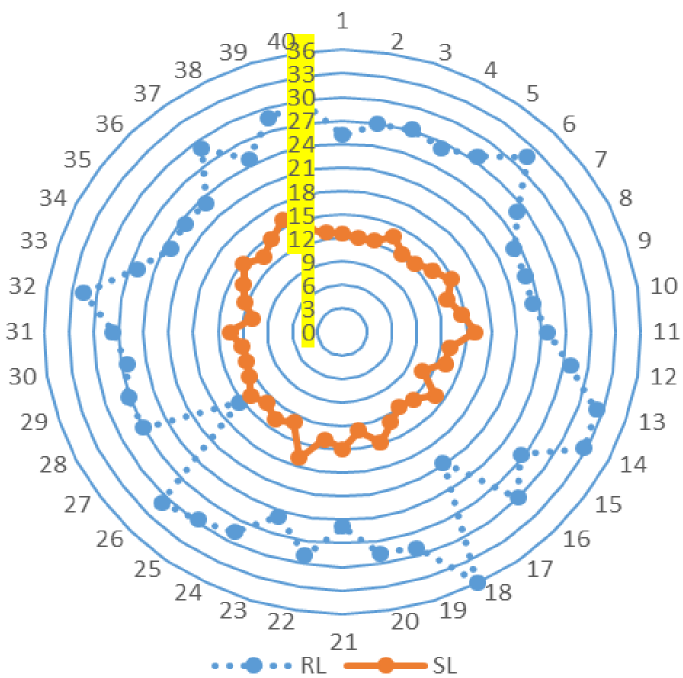

Figure 3: *RADAR analysis showing the performance of 40 spring wheat genotypes at seedling stage for root length (RL) and shoot length (SL) against limited water condition.*

Table 3: *Best and Worst performance of bread wheat genotype under limited water conditions.*

Traits	Genotype names and their higher Mean Values	Genotype names and their lower Mean Values
Shoot length (cm)	Hashim-2008 (16.09) followed by Sonara-64 (16.03) and BWL-0924 (16.03)	HD 2307 (11) and Chakwal-50 (10.87)
Root length (cm)	Pasban-90 (35.9) followed by Chakwal-50 (32.7) and C-586642 (32.2)	AARI-2011 (20.63) and Khyber-87 (15.33)
Fresh root weight (g)	Ass-11 (4.93) followed by Bakhar-2002 (4.80) and Chakwal-50 (3.97)	DPW-621-50 (0.24) and GA 2002 (0.20)
Fresh shoot weight (g)	Bakhar-2002 (2.93) followed by Chakwal-50 (2.83) and Ass-11 (2.83)	Abadgar-93 (0.41) and Khyber-87 (0.33)
Dry root weight (g)	Chakwal-50 (1.256) followed by Bakhtawar-94 (1.05) and Anza (0.93)	GA2002 (0.07) and BWL812
Dry shoot weight(g)	Chakwal-50 (0.41) followed by Ass-11 (0.34) and Bakhar2002 (0.30)	AARI-2011 (0.11) and PBN-51 (0.07)

Root related traits

To identify desirable wheat accessions for the breeding program for the development of drought tolerance and high-yielding genotypes, root length is a distinctive and appropriate attribute for selection. The wheat plant has two types of roots mechanisms. The seminal root system begins immediately after germination. After germination, adventitious roots appearing from the basal nodes. When the seed germinates, the root bursts through the coleorhizae and follows the emergence of 45 lateral seminal roots. Water shortage always affects plant in a way that it has to adjust its morphological, physiological and biochemical pathways by varying, switching on or switching off the gene expression as a comeback mechanism (Muhammad, 2010). Data recorded for root length in studied germplasm ranged from 15.33 cm to 35.90 cm (Pasban-90) in drought conditions as shown in Table 2. Results obtained for fresh root weight attribute in studied spring wheat genotypes ranged from 0.21 g to 4.93g (Ass-11) in drought as presented in Table 2. These outcomes are same with the findings of (Ahmed *et al*., 2020b). In studied germplasm, results obtained for dry roots weights attribute ranged from 0.07 g to 1.26 g (Chakwal-50) in drought conditions as displayed in Table 2. Root length is very imperative attribute for choice of drought resistant genotypes (Mujtaba *et al*., 2016). 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. 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. Liu *et al*. (2016) found during his studies the only survivor wheat cultivar during water shortage had produced deeper roots. In times of water scarcity, plants that can grow longer, deeper roots may survive well (Noorka, 2014). So, the behavior of accessions that indicated longer root length performed well even under water scarcity conditions.

Novelty Statement

Best performing genotypes would be additionally used in next generations for improved morphological indices conferring drought-tolerant genotypes.

Author's Contribution

Hafiz Ghulam Muhu-Din Ahmed: Conceptualization, formal analysis, writing - original draft, supervision, resources
Aziz Ullah: Formal analysis
Muhammad Asim Bhutta: Funding acquisition, visualization, investigation, writing - review and editing
Amna Bibi: Validation
Hafeez ur Rehman: Software
Umar Farooq: Data curation

Conflict of interest

The authors have declared no conflict of interest.

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