Research Article

Response of Wheat Genotypes Having Different Stature to Early Period Drought Stress

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Abstract | Drought is serious constrain to global food production and shortage of water at any stage of plant life can be damaging for growth, physiological processes and yield. Thus, present study was executed to determine the impact of drought on growth and yield of different wheat cultivars. The study was comprised of early drought treatment such as I_0 (control), I_1 (fist irrigation 30 days after sowing), I_2 (first irrigation 45 days after sowing) and I_3 (first irrigation 60 days after sowing) and wheat cultivars Faisalabad-2008 (standard height and low tillering), Td-1 (low height and low tillering) and Galaxy-2013 (standard height and high tillering). The results indicated that maximum leaf area index (LAI), crop growth rate (CGR), tillers (356.2 m^2), spikelet/spike (18.61), grains/spike (49.53), 1000-grain weight (44.4 g), biological yield (12.95 t ha^{-1}) and grain yield (4.61 t ha^{-1}) was recorded in control whereas lowest value for these parameters were recorded when first irrigation was applied 60 days after sowing. Among cultivars Galaxy-2013 performed well maximum LAI, CGR, plant height (83.42 cm), tillers (358 m^2), spikelet/spike (18.61), grains/spike (44.97), 1000 seed weight (43.4 g) and grain yield (4.42 t ha^{-1}), whereas Td-1 performed poorly with minimum LAI, CGR, plant height (71.10 cm), tillers (331 m^2), spikelet/spike (17.64), grains/spike (35.48), 1000 grain weight (35.50 g) and grain yield (3.14 t ha^{-1}). In conclusion cultivar Galaxy-2013 with standard height and high tillering can be grown in drought stress areas to get maximum wheat productivity.

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1. Introduction

Wheat is an essential source of food and provides an appreciable amount of protein, carbohydrates, zinc, fiber, calories, energy and fat globally (Chattha *et al*., 2017a; Hassan *et al*., 2019a, 2021a; Mohsin *et al*., 2021). Nonetheless, production of wheat across the continents is substantially decreasing owing to drought stress linked with climate change (Sadok *et al*., 2019; Sabella *et al*., 2020). Moreover, frequency of drought stress is contentiously soaring up owing to unpredictable rainfall and rapid change in climate patterns and increase in atmospheric temperature (Hassan *et al.*, 2021b). Drought stress reduces the crop productivity by decreasing the water uptake, leaf gas exchange and plant water status (Farooq *et al.*, 2017). Likewise, drought stress also decreases conductance of stomata which considerably increased temperature of leaves and leads to leaf wilting (Sehgal *et al.*, 2017). Moreover, drought stress decreases membrane stability, chlorophyll synthesis and subsequently photosynthesis (Samarah *et al.*, 2009; Awasthi *et al.*, 2014; Hassan *et al.*, 2020a). Additionally, water deficiency also induced the production of ROS (Mar *et al.*, 2010; Rasheed *et al.*, 2020; Mehmood *et al.*, 2021) which damage the cell membrane, and macro molecules including, proteins, lipids and DNA (Wu *et al.*, 2014).

Faced with rapid climate change and coupled with increased food demands need substantial increase in the wheat productivity (Semenov *et al.*, 2014; Wang *et al.*, 2018). Therefore, drought tolerant wheat cultivars is an imperious strategy to improve wheat productivity (Mwadzingeni *et al.*, 2016). A broad and multifaceted variation in the stature has been shown by the plants. Stature is all about overall size which includes height, tallness, and size (Victor *et al.*, 2008). In temperate cereal plants stature is predominantly controlled by tillering and plant height (Alqudah, 2016). The synthesis, accumulation, and translocation of photosynthates depend upon early plant growth, efficient photosynthetic structure and the degree of translocation into sink (grains). Water shortage has substantiated impacts on plant stature which depends on nature and duration of stress (Bartels and Souer 2004).

Importance of the wheat and issues which affect crop production directly or indirectly cannot be neglected. One of the major issues that our country is facing is drought stress. Improvement in the crop yield can be initiated by introducing better verities. Furthermore, latest verities have improved response to environmental stress. Keeping in mind all the environmental stresses and other issues, scientists and agriculturists are working on to improve wheat yield. Many new verities have been introduced which are better in field and also in production. Therefore, present study was designed to determine responses of different wheat genotypes having variable structures to early drought stress in wheat.

2. Materials and Methods

2.1 Location

The current study was performed at Agronomy Farm, University of Agriculture, Faisalabad. The study site had hot and humid summer and dry winter conditions (Hassan *et al.*, 2019b, 2020b) and further climatic conditions are given in Table 1. Before sowing soil samples (0-30 cm depth) were taken with soil augar and analyzed by methods of Homer and Pratt (1961) to determine the soil properties. The soil was sandy loam with pH 7.8, total nitrogen 0.014%, available phosphorus and potassium 16 and 172 mg kg^{-1}.

Table 1: Weather conditions during growing period.

Months	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Total rain fall (mm)
November	24.1	11.8	1.5
December	22.0	6.70	4.2
January	23.0	5.50	0
February	24.0	9.50	9.5
March	31.2	16.4	12.5
April	36.8	20.8	7.9

2.2 Crop husbandry

The study was executed in RCBD with a split plot arrangement having three replications. The study was comprised of different levels of drought stress; control (4 irrigations), fist irrigation 30 days after sowing, normal irrigation, first irrigation 45 days after sowing, then normal irrigation and first irrigation 60 days after sowing, then normal irrigation and different wheat varieties Faisalabad-2008 (standard height and low tillering), TD-1 (low height and low tillering) and Galaxy-2013 (standard height and high tillering). The soil was cultivated twice fallowed with planking to make the final seed. Wheat crop was sown on 5th December 2017 with a seed rate of 125 kg/ha. NPK fertilizer was applied at 100, 95, 75 kg/ha and complete amount of P and K and half of N was used at sowing time and rest of N was applied with the first irrigation.

2.3 Observations

One meter long row of wheat crop was harvested from each plot after an interval of fifteen days. The plants were separated into leaves and stems and sub-sample of leaves (5 g) was taken and leaf area index (LAI) was determined by methods of Watson (1947). Likewise, a sample of plants (10 g) was taken and oven dried and crop growth rate (CGR) was measured by methods of Hunt (1978). An area of one square meter was marked in each plot and number of tillers was counted. Likewise, ten spikes were also taken and spikelet's and grains/per spike was counted. Thousand grains were taken at random and weighed on digital balance to determine 1000 grain weight. Experimental plots were hand harvested and dried and afterwards weighed to measure biological yield and later on threshed and grain yield was determined by weighing and converted into ton per hectare basis.

2.4 Statistical analysis

The observations on the growth and yield traits were analyzed by Fisher's ANOVA and means were separated by LSD test at 5% probability (Steel *et al.*, 1997).

3. Results and Discussion

The results depicted that different level of early drought stress and cultivars had significant impact on the growth attributes of wheat cultivar. The maximum LAI and CGR throughout the growing period was recorded in control (full irrigation), whereas the lowest LAI and CGR throughout the growing period was noted when first irrigation was applied 60 DAS (Tables 2, 3). Similarly, among cultivars, Galaxy-2013 (standard height and high tillering) performed well and had maximum LAI and CGR throughout growing season and minimum LAI and CGR was recorded in TD-1 (low height and low tillering) (Tables 2, 3). The missing irrigation at any stage significantly reduced the LAI, CGR and plant height as compared to full irrigations. The imposition of drought stress at any growth stage reduces leaf expansion and this reduction in leaf expansion substantially reduced the LAI of wheat. Likewise, the reduction in LAI reduced the light harvesting and subsequent dry matter production and therefore resulted in reduction in CGR (Sharma *et al.*, 2019). The cultivar Galaxy-2013 had maximum LAI owing to longer leaves with more width as compared to other cultivars. Likewise, the longer leaves in Galaxy-2013 ensured the better light harvesting and assimilate production and thus resulted in more CGR. These outcomes are same with results of Bavec *et al.* (2007) they also noted significant difference among cultivar for LAI and CGR. Taller plants (88.29 cm) were recorded in control after that first irrigation was applied 30 DAS and shorter plants (76.73 cm) was recorded when first irrigation was applied 60 DAS (Table 3). Among wheat cultivars taller plants (83.42 cm) was recorded in Galaxy-2013 after that FSD-2008 and shorter plants (71.10 cm) was noted in Td-1 (Table 4). The reduction in plant height with skipping irrigation can be due to reduction in LAI and assimilates production (Bavec *et al.*, 2007). Similarly, Galaxy-2013 had maximum plant height owing to its genetic character to produce the taller plants as compared to other cultivars (Chattha *et al.*, 2017a, 2017b; Hassan *et al.*, 2018; Ilyas *et al.*, 2020; Ahmad *et al.*, 2021; Iqbal *et al.*, 2021).

Table 2: Effect of different irrigation intervals on leaf area index of wheat cultivars recorded at different intervals.

Irrigation levels	LAI 45 DAS	LAI 65 DAS	LAI 85 DAS	LAI 105 DAS
Control	2.33A	4.35 A	5.43 A	2.10A
Irrigation 30 DAS	2.17A	3.78 B	5.16 B	1.97C
Irrigation 45 DAS	1.89B	3.03 C	4.29 C	2.001B
Irrigation 60 DAS	1.78B	2.75 D	3.78 D	1.96 C
LSD at 0.5% *P*	0.20	0.24	0.19	0.09
Cultivars				
FSD-2008	2.13A	3.94 A	5.20 A	2.49 A
Galaxy-2013	1.92B	3.53 B	4.8 B	2.32 B
Td-1	1.72C	2.97 C	4.00 C	1.21 C
LSD at 0.5% *P*	0.12	0.16	0.15	0.17

Means with different letters differed at 0.05 *P* level. LAI: leaf area index, DAS: days after sowing.

Table 3: Effect of different irrigation intervals on crop growth rate (g m^{-2} day^{-1}) of wheat cultivars recorded at different intervals.

Irrigation levels	CGR 45-65 DAS	CGR 65-85 DAS	CGR 85-105 DAS
Control	11.74 A	14.57A	12.33A
Irrigation 30 DAS	10.90 B	13.53B	11.14B
Irrigation 45 DAS	10.31 C	12.75C	10.25C
Irrigation 60 DAS	9.54 D	11.65D	9.81D
LSD at 0.5% *P*	0.29	0.35	0.42
Cultivars			
FSD-2008	10.55 B	13.46 B	11.36B
Galaxy-2013	11.92 A	14.32 A	12.45A
Td-1	9.4 0C	11.6 0C	10.10C
LSD at 0.5% *P*	0.34	0.26	0.35

Means with different letters differed at 0.05 *P* level. LAI: leaf area index, DAS: days after sowing

The variable irrigation intervals and cultivars significantly affected yield components. The maximum productive tillers (356 m^2), spikelet/spike (20.73) and grains/spike (46.18) was recorded in control, whereas lowest productive tillers (325 m^2), spikelet/spike (16.88) and grains/spike (36.18) was recorded when first irrigation was applied 60 DAS (Table 4). Standard heighted and high tillering cultivar Galaxy-2013 had maximum productive tillers (358 m^2), spikelet/spike (18.16) and grains/spike (44.97) whereas low heighted and low tillering cultivar Td-1 has minimum productive tillers (331 m^2), spikelet/spike (17.64) and grains/spike (35.48) (Table 4). The skipping irrigation at early growth stages significantly the productive tillers, spikelets and grains/spike. Drought stress imposed at any growth stage negatively affect LAI, assimilates production, photosynthetic process and other plant physiological processes, therefore, all these reductions led to considerable reduction in the yield traits including tillers, grains and spikelets (Ali and Amin, 2007; Khokhar *et al*., 2010; Ngwako and Mashiqa, 2013). The cultivars also had substantiated difference for the yield traits and cultivar Galaxy-2013 performed well with maximum tillers, grains and spikelets owing to better LAI, dry matter and assimilates production as compared to other cultivars (Chattha *et al*., 2017a).

Table 4: Effect of different irrigation intervals on plant height, productive tillers, spikelet/spike and grains/spike of wheat.

Irrigation levels	Plant height (cm)	Productive tillers (m^2)	Spikelet/spike	Grains/spike
Control	88.29A	356.2 A	20.73A	46.18A
Irrigation 30 DAS	78.13B	355.0A	17.72B	42.91A
Irrigation 45 DAS	78.70B	354.0A	17.01B	42.38AB
Irrigation 60 DAS	76.73C	325.4B	16.88B	36.18B
LSD at 0.5% *P*	1.78	2.41	2.23	2.44
Cultivars				
FSD-2008	82.36A	353.5B	18.00	45.30A
Galaxy-2013	83.42A	358.6A	18.61	44.97A
Td-1	71.10B	330.8C	17.64A	35.48B
LSD at 0.5% *P*	2.12	2.54	NS	1.29

Means with different letters differed at 0.05 *P* level.

The maximum 1000 grain weight (44.4 g) and biological yield (12.45 t ha^{-1}) and grain yield (4.61 t ha^{-1}) was recorded in control and lowest values for these characters was noted when first irrigation was applied 60 DAS (Table 4). Among cultivars maximum 1000 grain weight (43.4 g), biological yield (10.70 t ha^{-1}) and grain yield (4.42 t ha^{-1}) was recorded in standard heighted and high tillering cultivar Galaxy-2013 and minimum grain weight, grain and biomass yield was recorded in low heighted and low tillering cultivar Td-1 (Table 5). The present decrease in seed weight was due to less and limited supply of assimilates which therefore led to production of grains with less weight (Taipodia and Singh, 2013). Moreover, maximum biological yield was reported in full irrigations, and missing irrigation reduced the biological yield which is consistent with findings of Ghanbari (2010). Grain yield is interplay of yield trait and maximum grain yield in full irrigation was due to maximum LAI, CGR and yield traits whereas reduction in yield with missing irrigations was due to reduction in yield traits (Mubeen *et al*., 2013; Ngwako and Mashiqa, 2013). A clear difference was also recorded among cultivars for grain weight, grain and biomass yield. Cultivar Galaxy-2013 performed well with maximum grain yield owing to better LAI, CGR, assimilates and yield parameters, including tillers, grains, spikelets and grain weight. These outcomes are same with results of Chattha *et al*. (2017a) they also noted significant difference among cultivars for the grain weight seed and biological yield.

Table 5: Effect of different irrigation intervals on 1000 grain weight, biological yield, grain yield and harvest index of wheat cultivars.

Irrigation levels	1000 grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index (%)
Control	44.4A	12.45A	4.61A	36.33B
Irrigation 30 DAS	40.5B	12.22A	4.18B	36.84B
Irrigation 45 DAS	37.0C	9.50B	3.50C	35.36C
Irrigation 60 DAS	34.4D	7.24C	2.60D	37.96 A
LSD at 0.5% *P*	2.22	1.94	0.33	1.13
Cultivars				
FSD-2008	42.5A	10.92A	3.61B	38.09A
Galaxy-2013	43.4B	10.70A	4.42A	37.42A
Td-1	35.5C	9.44B	3.14C	34.35B
LSD at 0.5% *P*	1.02	0.63	0.26	1.04

Means with different letters differed at 0.05 *P* level.

Conclusions and Recommendations

Delayed irrigation had negative impacts on the growth, yield and yield traits of wheat crop. Cultivar Galaxy-2013 (Standard height and high tillering) performed appreciably well and had better growth and yield and yield traits. Therefore, cultivars with standard height and high tillering can be used in drought affected areas to improve the wheat production.

Novelty Statement

Plant stature plays an imperious role in growth and productivity. However, limited studies are conducted to determine the impact of genotypes with different stature on growth and yield under drought conditions. Therefore, we evaluated the response of wheat genotypes having different statures to drought stress conditions.

Author's Contribution

Mubeen Zahra: Performed the experiment.
Muhammad Umer Chattha and Imran Khan: Conceived and designed the experiment and wrote original draft.
Muhammad Nawaz, Muhammad Bilal Chattha, Muhammad Ashraf Bhatti, Abdul Rehman, Faryal Ahmed, Faran Muhammad and Mina Kharal: Reviewed and edited.
Muhammad Umair Hassan: Wrote original draft.

Conflict of interest
The authors have declared no conflict of interest.

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