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Effect of Drought Stress on Fertile Tillers of Wheat Genotypes (*Triticum aestivum* L.)

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ABSTRACT

Wheat is staple food in many countries and a key cereal crop of the world. In Asia and south Asian areas wheat is the second leading cereal crop and it is providing 68% of energy. It provides trace elements, carbohydrates and protein to our body. Drought stress is a major problem and threating crop productivity around the world. It affects wheat crop at all growth stages and reduces its yield potential from 10-90%. So, there is dire need to develop drought tolerant wheat varieties. This study was conducted by using ten high yielding varieties of wheat. These varieties were sown under normal conditions and drought stress under randomized complete block design with three replications. The data was collected for plant height, number of productive tillers per plant, spike length, peduncle length, number of spikelets per spike, number of grains per spike, yield per spike, yield per plant, 1000-grain weight. Analysis of variance was executed and results were analyzed. The results showed that all characters were showing highly significant results for irrigation and genotypes except spike length. Interaction of irrigation and genotypes showed non-significant results for grains per spike, grain yield per spike, yield per plant and 1000-grain weight but show significant for spikelets per spike and highly significant for plant height number of tillers per plant and peduncle length. The graphical representation of genotypes under normal condition and drought stress was done by mean values. Inqlab-91 performed good for grain yield, yield per plant and 1000-grain weight under both levels of irrigation followed by Galaxy-13. Genotypes C-273 and C-250 were tallest under normal irrigation. Thus, results obtained from this research will be useful in selecting best genotypes for rainfed and water stress environment in future breeding programs.

Key words: Wheat, Drought, Tillers

INTRODUCTION

Wheat (*Tritium aestivum* L.) belongs to the grass family (*poaceae*) and an important cereal crop in many countries. Wheat attributes 35% of total world food consumption (Mohammadi-joo *et al.,* 2015). In Asia and South Asian areas, it is the second leading cereal crop and it is providing 68% of energy (Shewry, 2009). Wheat plays a vital role in human diet in the form of protein, carbohydrates and calories. Due to its wider adaptation wheat is sown as a rain-fed and irrigated crop (Monneveux *et al.,* 2012). Wheat is sown on over and above the area of 215000 thousand hac/anum with the production of 725000 thousand tons in the year 2014 and it stands broadly grown crop in the world. It is the essential food in many countries and serving 30% of the world population. Among all the genotypes bread wheat individually gives the 95% of world wheat production (FAOSTAT, 2015). Wheat supply will be a challenging factor in future as the fast-growing world population will require 60% increase in yield by 2050 than today (McKersie, 2015).

Drastic changes occurred in climate and fast increasing population leads to the food security worldwide (Lesk *et al.,* 2016). Due to changes in climate the reduction in precipitation and rainfall caused the global drought stress (Lobell *et al.,* 2011). This stress ultimately decreased the crop yield by affecting the plant physiology and growth patterns (Velikova *et al.*, 2000; Barnabás *et al.*, 2008). Recent study from 1985-2015 showed 20-40 % decreased in production of wheat and maize due to low water stress (Daryanto *et al.,* 2016). World average temperature has increased by 0.85°C from last thirty years. Rising greenhouse gases alongwith increase in CO_2 concentration became a major issue (Lal, 2004; Friedlingstein *et al.*, 2010).

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These stresses decreased the wheat crop production and due to change in temperature and water stress 6% decline occurred in wheat productivity (Asseng *et al*., 2015; Challinor *et al*., 2014). Drought stress is a major problem and 43% area in the world is affected by it. In Pakistan 15000 thousand hectares is under various degree of water stress, which is the 75% of total cultured area. It causes yield reduction in many crops depending upon the duration and intensity of stress period. Wheat is an important cereal crop of Asia, with great yield potential under optimal conditions and due drought its yield potential reduces from 10 to 90% (Fatima *et al.,* 2018). It showed negative impact on seedling stage of crop and resulted in poor germination (Hamed *et al*., 2006). The reduction occurred at early growth stage (Okçu *et al*., 2005; Manickavelu *et al*., 2006; Zeid and Shedeed, 2006).

Drought stress decreased the yield due to the loss of turgor pressure and limited the cell growth by impairing the mitosis (Taiz and Zeiger, 2006; Nonami, 1998). It reduced the leaf size by limiting the leaf expansion (Rucker *et al*., 1995). Water stress severely affects the plant fresh weight and reduced the dry matter contents (Ke-li *et al*., 2006). Plant height was decreased drastically under drought stress in cereals (Budak *et al*., 2015; Kamara *et al*., 2003).

Drought stress decreased the crop production in South Africa (Liwani *et al.*, 2019). Water shortage at four stages of plant growth severely affects the plant productivity but the shortage at anthesis caused drastic reduction in pollination and grain formation. The plant photosynthesis activity lowered due to water stress which caused reduction in plant radiation use efficiency (Akram, 2011). water stress caused the yield reduction and during developing a breeding program for drought resistant cultivar, knowledge about the tolerance mechanism and its physiology is a key factor (Clarke *et al.*, 1984; Yoshida *et al.*, 2004). Grain yield is most affected parameter and the major concern of a breeder and can be improved by enhancing plant productivity (Dorigo and Blum, 2005). Thus, the objectives of present study was

1. To identify the varieties which have less effect on fertile tillers under drought condition.
2. To screen out the drought tolerant genotypes which can be sown in future to increase the crop production

MATERIALS AND METHODS

The experiment was conducted to check the effect of drought on the yield and yield related parameters of 10 varieties of bread wheat. Experiment was executed during the Rabi season 2019-20 in the field of department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan, in which these varieties of wheat were sown.

1. Inqlab-91	2. Lasani-08
3. Zincol	4. Eucora-70
5. T-9	6. C-250
7. C-273	8. Pak-81
9. Johar-16	10. Galaxy-13

The experiment was executed in randomized complete block design in which treatments were allocated randomly by random number method. The seed of these varieties was sown with dibbler to maintain (P×P and R×R) distance in the field. The experiment was conducted in two plots. One plot was kept in drought condition (Withholding irrigation) and the other plot was provided with normal condition of watering. Five plants from each genotype were selected for data analysis.

Data was taken at maturity on different parameters i.e.

1. Plant height
2. Number of Productive tillers per plant
3. Spike length
4. Peduncle length
5. Number of spikelet per spike
6. Number of Grains per spike
7. Yield per spike
8. Yield plant^{-1}
9. 1000-grain weight

Data Collection

Data was collected from the field experiment of 10 genotypes grown under normal irrigation and drought stress.

Plant Height

Data of each genotype was collected from the field and plant height is the major affected trait by drought. At plant full maturity stage, the data for the plant height was calculated with the help of meter rod in centimeters (cm). it was taken from ground to the last tip of spikelet and the awns were excluded. In each replication plant height of five plants with mother spike was calculated and the average value was computed and further analyzed.

Total Number of Fertile Tillers

At plant maturity total number of fertile tillers of five plants were counted manually from each replication. The average value of total number of fertile tillers per plant was taken for further evaluation and analyzed.

Spike Length

The data of 10 wheat genotypes was computed grown in three replications under normal irrigation and drought stress. Spike length of mother tillers was taken with the help of meter rod in centimeters. In spike length measurement awns were excluded. It was taken from the base of spike to the tip of last spikelet. The average values of five plants were taken for each genotype.

Peduncle Length

At plant maturity the data for peduncle length was computed with the help of meter rod in centimeters. The peduncle length was taken from the last node to the base of spike. The average value was taken for each genotype.

Spikelets Per Spike

The data was collected for 10 genotypes grown with three replications under normal irrigation and drought stress. At plant maturity stage the number of spikelets per spike were counted manually from mother spike of each plant. The average value of five lines was taken for each genotype.

Grains Per Spike

For number of grains all spikes were threshed separately of each guarded plant and counted. Number of grains were counted manually and the average value of five lines was taken for each replication.

Yield Per Spike

The mother spike was taken for measuring yield per spike of each plant and threshed separately. Then the threshed grains were weighed by using electronic balance in grams. Yield per spike showed direct relation with plant biological yield. The average of five plant were taken for each replication and analyzed.

Grain Yield Per Plant

All spikes of a plant were harvested, threshed and then weighed collectively to measure the grain yield per plant with the help of electronic balance in grams. In each replication average values of five plants were computed for grain yield.

1000-grain Weight

The seed of each plant was threshed separately and 1000 seeds were taken. The weight of 1000 grains were taken with electronic balance in grams. The average value of five plants for thousand grain weight was computed.

Statistical Analysis

Data of 10 genotypes was collected from the field experiment and was exposed to analysis of variance (Steel *et al*., 1997) to evaluate the genotypic differences for these traits. The data of mean value was represented by graphs. Graphical approach of statistics was used.

RESULTS AND DISCUSSION

Analysis of variance is a collection of statistical models and their associated estimation procedures used to analyze the differences among group means in a sample. ANOVA was developed by statistician and evolutionary biologist Ronald Fisher.

Analysis of variance was done for the genotypes, irrigation and their interaction under normal irrigation and drought stress. The results showed that all characters were showing highly significant results for irrigation and genotypes except spike length which shows non-significant results for Genotypes. Interaction of irrigation and genotypes showed no-significant results for grains per spike, grain yield per spike, yield per plant and 1000-grain weight but show significant for spikelets per spike and highly significant for plant height number of tillers per plant and peduncle length.

Bennani *et al.* (2016) studied the effect of drought stress on forty genotypes of wheat. ANOVA results were significant for agronomic traits under stressed conditions. Plant biomass and harvest index were non-significant parameters. Positive correlation value was recorded for 1000 grain weight and biomass under normal conditions. Haque *et al.* (2016) also investigated the behavior of rice genotypes under drought applied at vegetative and reproductive growth stages. Significant differences for phenological, morphological and agronomic traits were observed when subjected to reproductive stage stress.

Graphical Representation of 10 Wheat Genotypes for Means under Drought Stress and Normal Irrigation

Mean values were calculated from the replicated data which was taken from the field experiment of 10 genotypes for all yield related traits under two irrigations, normal and drought. The graphs were made by the mean values and the results were computed to check the variability among genotypes for traits.

The mean value graphs of 10 genotypes showed that C-273 has maximum plant height under normal irrigation followed by C-250. Genotype Inqlab-91 performed better under both conditions of irrigation for all taken traits. Eucora-70 was most sensitive genotype under drought stress.

Plant Height

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for plant height is shown in Fig. 1. Differences were observed in all genotypes for height ranges from 110.68 to 86.75. Maximum value for plant height in normal irrigation was observed for C-273 (122.3) followed by C-250 (118.70), Inqlab-91 (111.63), Zincol (107.63) and Pak-81 (105.57). Minimum value for plant height under normal irrigation was observed for Eucora-70 (86.23) followed by Lasani-08 (92.53), T-9 (93.67), Galaxy-13 (95.93) and Johar-16 (98.83). Under drought stress, the value of plant height ranges from 100.53 to 79.93. Minimum plant height observed for T-9 (79.93) followed by Johar-16 (82.03), Lasani-08 (82.10), Galaxy-13 (82.50), Pak-81 (86.20). highest value for plant height under stress was observed for Inqlab91 (100.53) followed by C-250 (100.47), C-273 (99.23), Zincol (90.47), Eucora-08 (87.27).

Number of Fertile Tillers per Plant

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Tillers per Plant is shown in Fig. 2. Differences were observed in all genotypes for number of Tillers per Plant ranges from 20.00 to 7.33. Maximum value Tillers per Plant for in normal irrigation was observed for C-273 (20.00) followed by Inqlab-91 (18.26), C-250 (17.37), Galaxy-13 (16.02) and Pak-81 (14.66). Minimum value for Tillers per Plant under normal irrigation was observed for Eucora-70 (7.33) followed by Johar-16 (8.33), T-9 (11.37), Lasani08 (12.66) and Zincol (13.33). Under drought stress, the value of plant height ranges from 5.15 to 9.37. Minimum Tillers per Plant observed for T-9 (5.15) followed by Johar-16 (6.74), Lasani-08 (6.22), Zincol (7.22), Pak-81 (7.37). highest value for Tillers per Plant under stress was observed for C-250 (9.37) followed by C-273 (8.93), Inqlab-91 (8.59), Galaxy-13 (8.03), Eucora-08 (7.55).

Spike Length

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Spike Length is shown in Fig. 3. Differences were observed in all genotypes for Spike Length ranges from 13.23 to 9.43. Maximum value for Spike Length in normal irrigation was observed for Galaxy-13 (13.23) followed by C-250 (12.90), C-273 (12.83), and Pak-81 (12.53). Minimum value for Spike Length under normal irrigation was observed for Eucora-70 (9.43) followed by Inqlab-91 (11.00), T-9 (11.67), Zincol (12.30), Lasani-08 (12.33) and Johar-16 (12.40). Under drought stress, the value of Spike Length ranges from 10.27 to 6.33. Minimum Spike Length observed for

Table 1: Analysis of variance for Plant height under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	323.47	161.73		
Irrigation	1	3030.28	3030.28	184.71**	0
Genotypes	9	5000.26	555.58	33.87**	0
irrigation*genotypes	9	586.3	65.14	3.97**	0.0012
Error	38	623.4	16.41		
Total	59	9563.72			

P<0.05 Significant P<0.01 Highly Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 2: Analysis of variance for Tillers per Plant under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	80.66	40.331		
Irrigation	1	617.86	617.861	119.41**	0
Genotypes	9	353.74	39.304	7.6**	0
irrigation*genotypes	9	158.23	17.581	3.4**	0.0038
Error	38	196.62	5.174		
Total	59	1407.11			

P<0.05 Significant P<0.01 Highly Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 3: Analysis of variance for Spike length under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	11.444	5.722		
Irrigation	1	274.776	274.776	106**	0
Genotypes	9	9.617	1.069	0.41 ns	0.9206
irrigation*genotypes	9	65.481	7.276	2.81 ns	0.125
Error	38	98.509	2.592		
Total	59	459.827			

P<0.05 Significant P<0.01 Highly Significant P>0.05 Non-Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 4: Analysis of variance for Peduncle length under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	139.25	69.63		
Irrigation	1	1473.12	1473.12	189.54**	0
Genotypes	9	578.05	64.23	8.26**	0
irrigation*genotypes	9	350.73	38.97	5.01**	0.0002
Error	38	295.34	7.77		
Total	59	2836.49			

P<0.05 Significant P<0.01 Highly Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 5: Analysis of variance for Spikelets per Spike under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	0.225	0.1125		
Irrigation	1	32.531	32.5312	9.25**	0.0042
Genotypes	9	74.001	8.2223	2.34*	0.0329
irrigation*genotypes	9	72.795	8.0884	2.3*	0.0356
Error	38	133.584	3.5154		
Total	59	313.136			

P<0.05 Significant P<0.01 Highly Significant. Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Pak-81 (6.33) followed by Galaxy-13 (6.67), T-9 (6.70), Johar-16 (7.17), Lasani-08 (7.23). highest value for Spike Length under stress was observed for Eucora08 (10.27) followed by Inqlab-91 (9.17), C-273 (8.37), Zincol (8.03), C-250 (7.90).

Table 6: Analysis of variance for Grains per Spike under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	364	181.98		
Irrigation	1	7455.3	7455.34	258.44**	0
Genotypes	9	2243.1	249.24	8.64**	0
irrigation*genotypes	9	287.1	31.9	1.11ns	0.382
Error	38	1096.2	28.85		
Total	59	11445.8			

P<0.05 Significant P<0.01 Highly Significant P>0.05 Non-Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 7: Analysis of variance for Yield Per Spike under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	0.0887	0.0444		
Irrigation	1	24.0034	24.0034	272.72**	0
Genotypes	9	5.794	0.6438	7.31**	0
irrigation*genotypes	9	1.1474	0.1275	1.45 ns	0.2027
Error	38	3.3445	0.088		
Total	59	34.3781			

P<0.05 Significant P<0.01 Highly Significant P>0.05 Non-Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 8: Analysis of variance for Grain Yield per Plant under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	77.12	38.56		
Irrigation	1	2918.2	2918.2	129.11**	0
Genotypes	9	1148.6	127.62	5.65**	0.0001
irrigation*genotypes	9	80.81	8.98	0.4 ns	0.9287
Error	38	858.92	22.6		
Total	59	5083.64			

P<0.05 Significant P<0.01 Highly Significant P>0.05 Non-Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Table 9: Analysis of variance for 100-Grain Weight under normal irrigation and drought stress

SOV	DF	SS	MS	F	P
Replications	2	56.24	28.12		
Irrigation	1	2692.73	2692.73	102.69**	0
Genotypes	9	1016.31	112.92	4.31**	0.0007
irrigation*genotypes	9	69.65	7.74	0.3 ns	0.9718
Error	38	996.41	26.22		
Total	59	4831.35			

P<0.05 Significant P<0.01 Highly Significant P>0.05 Non-Significant, Where DF= degree of freedom, SOV= source of variation, SS= total sum of squares, MS= mean sum of squares

Peduncle Length

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Peduncle Length is shown in Fig. 4. Differences were observed in all genotypes for Peduncle Length ranges from 41.03 to 27.90. Maximum value for Peduncle Length in normal irrigation was observed for Inqlab-91 (41.03) followed by C-250 (40.43), C-273 (40.40), and Zincol (39.33). Minimum value for Peduncle Length under normal irrigation was observed for Eucora-70 (27.90) followed Lasani-08 (31.33), T-9 (32.0), Johar-16 (34.33), Galaxy (36.77) and Pak-81 (37.6). Under drought stress, the value of Peduncle Length ranges from 31.57 to 20.90. Minimum Peduncle Length observed for T-9 (20.9) followed by Lasani-08 (21.83), Pak81 (22.37), Johar-16 (24.97) and Zincol (26.73).

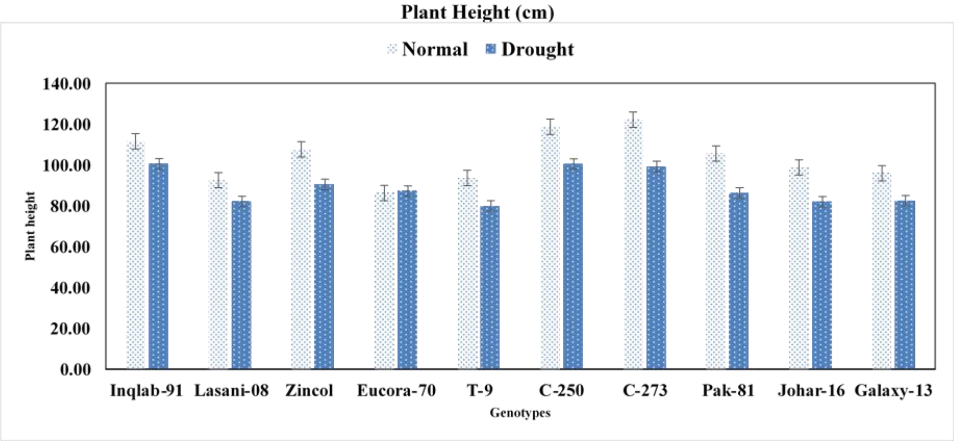

Fig. 1: Average values of 10 genotypes of wheat under two levels of irrigations for plant height viz. normal and drought

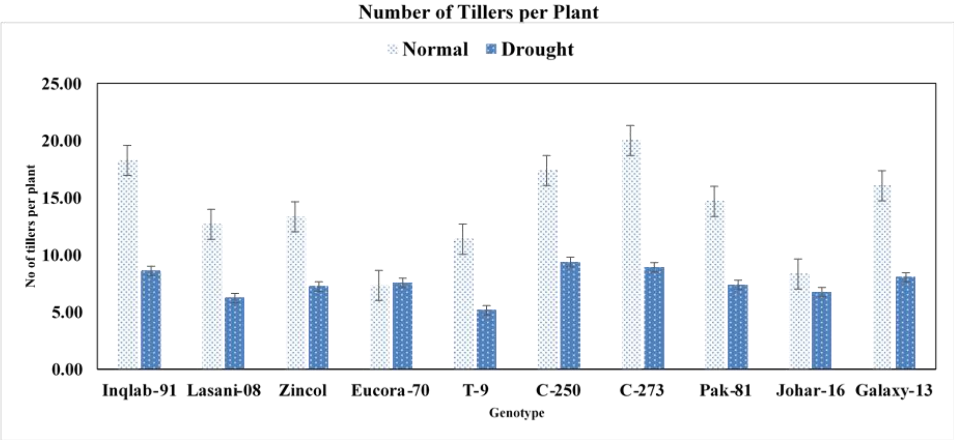

Fig. 2: Average values of 10 genotypes of wheat under two levels of irrigations for Tillers per Plant viz. normal and drought

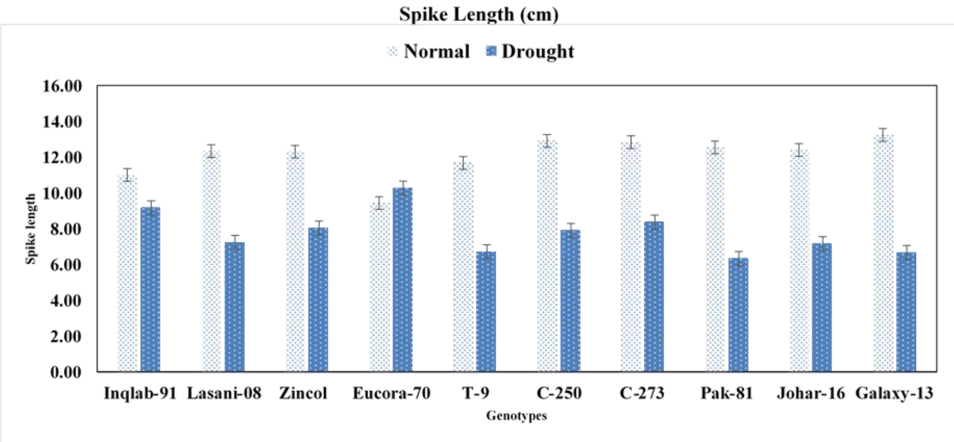

Fig. 3: Average values of 10 genotypes of wheat under two levels of irrigations for Spike length viz. normal and drought

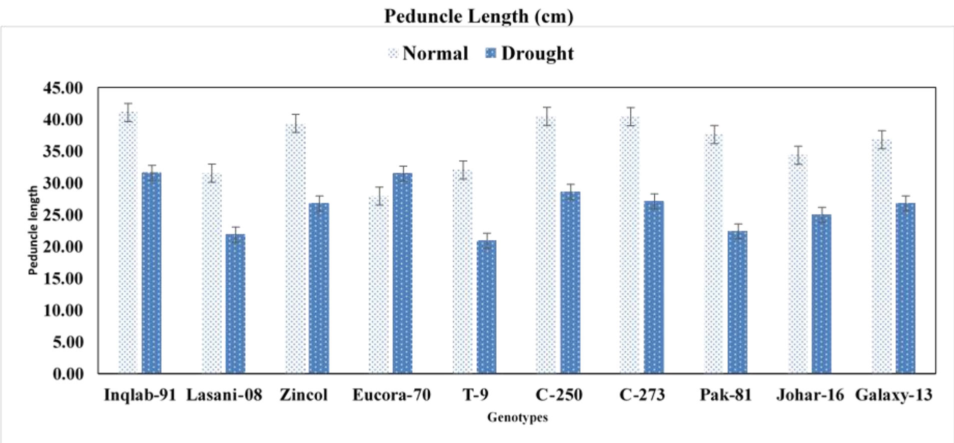

Fig. 4: Average values of 10 genotypes of wheat under two levels of irrigations for peduncle length viz. normal and drought

highest value for Peduncle Length under stress was observed for Inqlab-91 (31.57) followed by Eucora-08 (31.43), C-250 (28.57), C-273 (27.07) and Galaxy-13 (26.77).

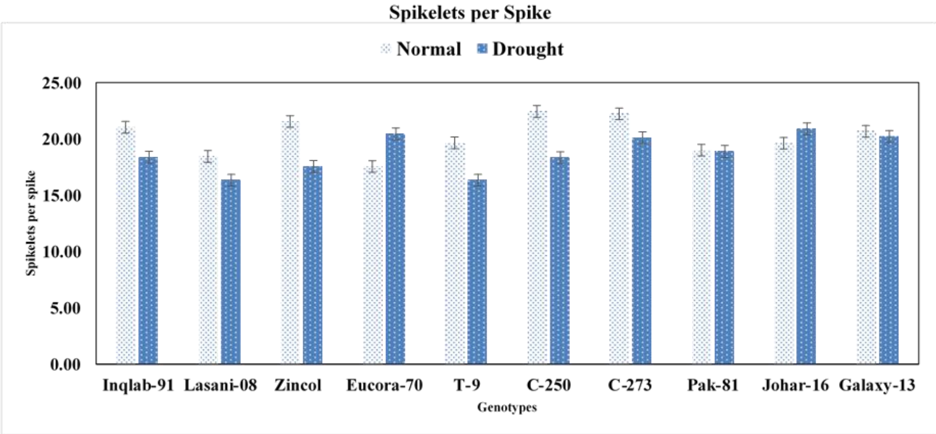

Fig. 5: Average values of 10 genotypes of wheat under two levels of irrigations for Spikelets per Spike viz. normal and drought

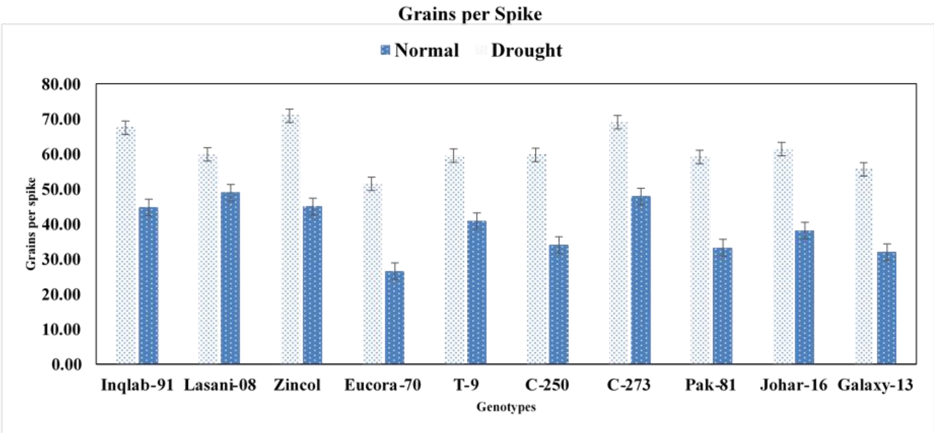

Fig. 6: Average values of 10 genotypes of wheat under two levels of irrigations for Grains per Spike viz. normal and drought

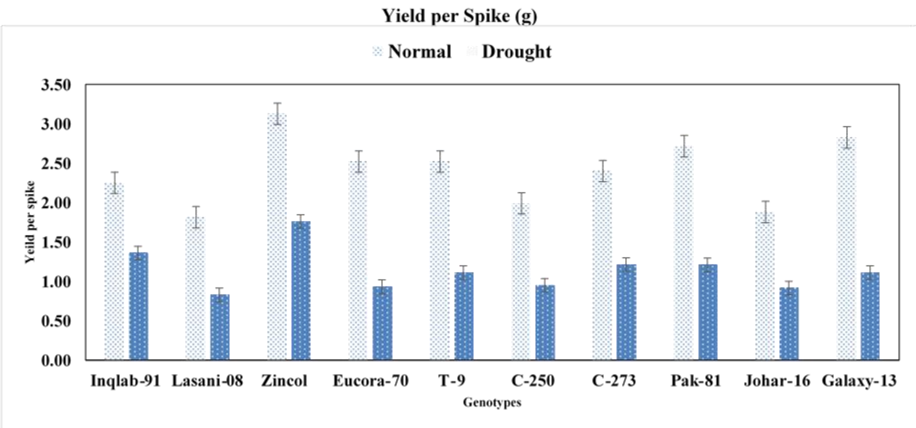

Fig. 7: Average values of 10 genotypes of wheat under two levels of irrigations for Yield per Spike viz. normal and drought

Spikelets Per Spike

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Spikelets per Spike is shown in Fig. 5. Differences were observed in all genotypes for Spikelets per Spike ranges from 22.44 to 17.55. Maximum value for Spikelets per Spike in normal irrigation was observed for C-250 (22.44) followed by C-273 (22.22), Zincol (21.55) and Inqlab-91 (21.04). Minimum value for Spikelets per Spike under normal irrigation was observed for Eucora-70 (17.55) followed by Lasani-08 (18.44), Pak-81 (19.00), and Johar-16 (19.61). Under drought stress, the value of Spikelets per Spike ranges from 20.89 to 16.33. Minimum Spikelets per Spike observed for Lasani-08 (16.33), T-9 (16.33) followed by Zincol (17.55), C-250 (18.33) and Inqlab-91 (18.37). highest value for Spikelets per Spike under stress was observed for Johar-16 (20.89) followed by Eucora-70 (20.44), Galaxy-13 (20.22) and Pak81 (18.89).

Number of Grains per Spike

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Number of Grains per Spike is shown in Fig. 6. Differences were observed in all genotypes for Number of Grains per Spike ranges from 70.81 to 51.44. Maximum value for Number of Grains per Spike in normal irrigation was observed for Zincol (70.81) followed by C-273 (69.83) and Inqlab-91 (67.44). Minimum value for Number of Grains per Spike under normal irrigation was observed for Eucora-70 (51.44), Galaxy-13 (55.54) followed by Pak-81 (59.11) and T-9 (59.4). Under drought stress, the value of Number of Grains per Spike ranges from 48.88 to 26.51. Minimum Number of Grains per Spike observed for Eucora-70 (26.51) followed by Galaxy-13 (31.89) and Pak-81 (33.19). Highest value for Number of Grains per Spike under stress was observed for Lasani-08 (48.88) followed by C-273 (47.91), Zincol (44.93) and Inqlab-91 (44.6).

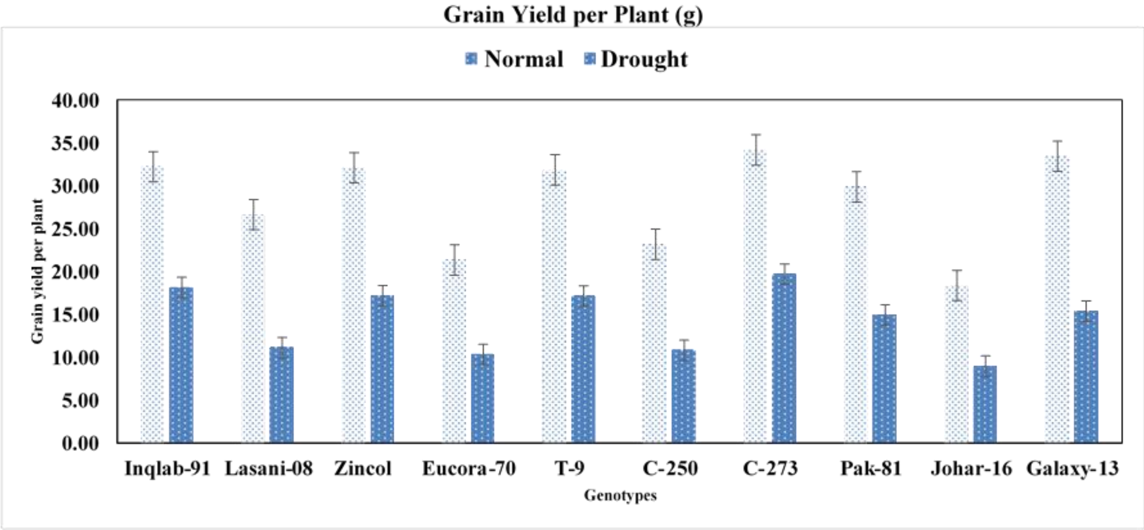

Fig. 8: Average values of 10 genotypes of wheat under two levels of irrigations for Grain yield per plant viz. normal and drought

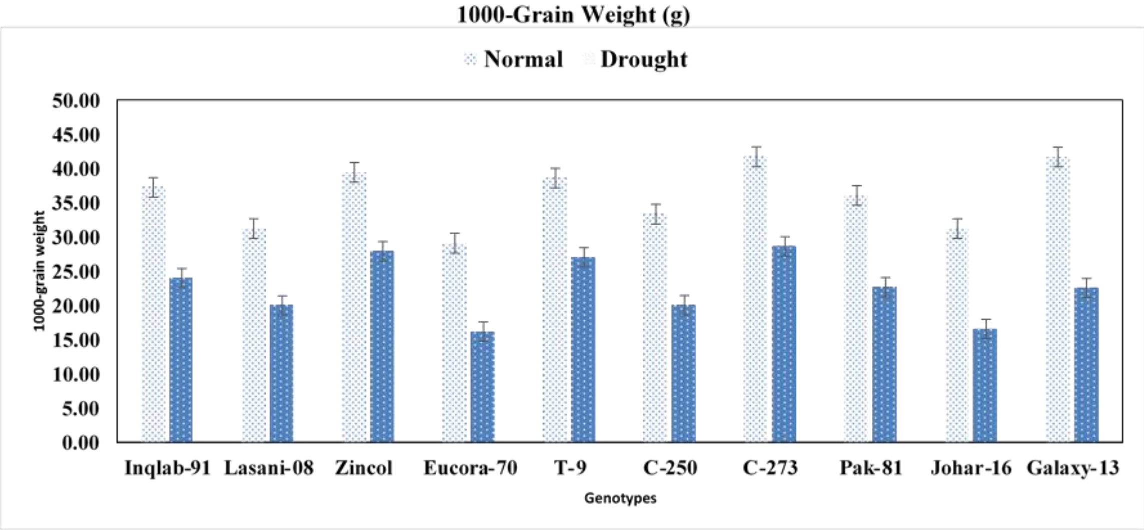

Fig. 9: Average values of 10 genotypes of wheat under two levels of irrigations for 1000-grain Weight viz. normal and drought

Yield Per Spike

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Yield per Spike is shown in Fig. 7. Differences were observed in all genotypes for Yield per Spike ranges from 3.13 to 1.81. Maximum value for Yield per Spike in normal irrigation was observed for Zincol (3.13) followed by Galaxy-13 (2.83), Pak-81 (2.72) and T-9 (2.52). Minimum value for Yield per Spike under normal irrigation was observed for Lasani-08 (1.81) followed by Johar-16 (1.88) and C-250 (2.25). Under drought stress, the value of Yield per Spike ranges from 1.76 to 0.83. Minimum Yield per Spike observed for Lasani-08 (0.83) followed by Johar-16 (0.92) and Eucora-70 (0.93). highest value for Yield per Spike under stress was observed for Zincol (1.76) followed by Inqlab-91 (1.36), C-273 (1.21), Pak-81 (1.2) and T-9 (1.11).

Yield Per Plant

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for Yield per Plant is shown in fig.8. Differences were observed in all genotypes for Yield per Plant ranges from 34.17 to 18.37. Maximum value for Yield per Plant in normal irrigation was observed for C-273 (34.17) followed by Galaxy-13 (33.43), Inqlab-91 (32.21), and Zincol (32.10). Minimum value for Yield per Plant under normal irrigation was observed for Johar16 (18.37) followed by Eucora-70 (21.34), C-250 (23.15), Lasani-08 (26.363) and Pak-81 (29.86). Under drought stress, the value of Yield per Plant ranges from 19.68 to 8.96. Minimum Yield per Plant observed for Johar-16 (8.96) followed by Eucora-70 (10.33), C-250 (10.80) and Lasani-08 (11.10). highest value for Yield per Plant under stress was observed for C-273 (19.68) followed by Inqlab-91 (18.11) and Zincol (17.18).

1000-Grain Weight

Mean value graphs of 10 wheat genotypes with two level of irrigations, drought and normal for 1000-Grain Weight is shown in Fig. 9. Differences were observed in all genotypes for 1000Grain Weight ranges from 29.11 to 41.72. Maximum value for 1000-Grain Weight in normal irrigation was observed by C-273 (41.72), Galaxy-13

(41.68) followed by Zincol (39.41), T-9 (38.61), Inqlab-91 (37.2), and Pak-81 (36.06). Minimum value for 1000-Grain Weight under normal irrigation was observed for Eucora-70 (29.11) followed by C-250 (33.32), Lasani-08 (31.25) and Johar-16 (31.240). Under drought stress, the value of 1000-Grain Weight ranges from 28.63 to 16.19. Maximum 1000-Grain Weight observed for C-273 (28.63), Pak-81 (22.67) followed by Zincol (27.94), T-9 (27.03), Lasani-08 (20.02). Minimum value for 1000Grain Weight under stress was observed for Eucora-08 (16.19) followed by Johar-16 (16.56), C-250 (20.03), Inqlab-91 (24.00), Galaxy-13 (22.56).

Graphical representation of 10 wheat genotypes revealed that productive tillers per plant showed positive association with grain yield and high number of fertile spikelets can improve yield (Zaheer and Ahmad 1991). Number of grains increased the grain yield documented by (Larik, 1979). Grain yield is most influenced by number of grains per spike supported by (Smoček, 1977; Ehdaie and Waines, 1989; Naserian *et al.*, 2007; Kotal *et al.*, 2010). Number of kernels had positive correlation with plant yield under drought stress observed by (Wang *et al.*, 1991; Denčić *et al.*, 2000). Under both conditions of irrigation, normal and drought grain numbers seemed to be most important trait associated with grain yield (Denčić *et al.*, 2000; Slafer and Andrade, 1991; Sen and Toms, 2007).

REFERENCES

Akram M, 2011. Growth and yield components of wheat under water stress of different growth stages. Bangladesh Journal of Agricultural Research, 36(3), 455-468.

Asseng S, F Ewert, P Martre, RP Rötter, DB Lobell, D Cammarano and Y Zhu, 2015. Rising temperatures reduce global wheat production. Nature Climate Change, 5(2), 143-147.

Barnabás B, K Jäger and A Fehér, 2008. The effect of drought and heat stress on reproductive processes in cereals. Plant, Cell & Environment, 31(1), 11-38.

Bennani S, N Nsarellah, A Birouk, H Ouabbou and W Tadesse, 2016. Effective selection criteria for screening drought tolerant and high yielding bread wheat genotypes. Universal Journal of Agricultural Research, 4(4), 134-142.

Budak H, B Hussain, Z Khan, NZ Ozturk and N Ullah, 2015. From genetics to functional genomics: improvement in drought signaling and tolerance in wheat. Frontiers in Plant Science, 6, 1012.

Challinor AJ, J Watson, DB Lobell, SM Howden, DR Smith and N Chhetri, 2014. A metaanalysis of crop yield under climate change and adaptation. Nature Climate Change, 4(4), 287-291.

Clarke JM, F Townley-Smith, TN McCaig and DG Green, 1984. Growth analysis of spring wheat cultivars of varying drought resistance 1. Crop Science, 24(3), 537-541.

Daryanto S, L Wang and PA Jacinthe, 2016. Global synthesis of drought effects on maize and wheat production. PloS one, 11(5), e0156362.

Denčić S, R Kastori, B Kobiljski and B Duggan, 2000. Evaluation of grain yield and its components in wheat cultivars and landraces under near optimal and drought conditions. Euphytica, 113(1), 43-52.

Dorigo M and C Blum, 2005. Ant colony optimization theory: A survey. Theoretical Computer Science, 344(2-3), 243-278.

Ehdaie B and JG Waines, 1989. Genetic variation, heritability and path-analysis in landraces of bread wheat from southwestern Iran. Euphytica, 41(3), 183-190.

FAOSTAT, 2015. Food and agriculture organization of the united nations statistics division. Rome, Italy.

Fatima M, Z Ahmed, M Aslam and M Zaynab, 2018. Drought Effect and Tolerance Potential of Wheat: A Mini-Review. Internatonal Journal Nanotechnol. Allied Science 2(2), 16-21.

Friedlingstein P, RA Houghton, G Marland, J Hackler, TA Boden, TJ Conway and C Le Quéré, 2010. Update on CO2 emissions. Nature Geoscience, 3(12), 811-812.

Hamed HF, S Kaya and J Starzyk, 2006. Compact tunable current-mode analog circuits using DGMOSFETs. In *2006 IEEE international SOI Conferencee Proceedings* (pp. 69-70). IEEE.

Haque KS, MA Karim, MN Bari and MR Islam, 2016. Genotypic variation in the effect of drought stress on phenology, morphology and yield of aus rice. International Journal Bioscience 8(6), 73-82.

Kamara AY, A Menkir, B Badu-Apraku and O Ibikunle, 2003. The influence of drought stress on growth, yield and yield components of selected maize genotypes. The Journal of Agricultural Science, 141(1), 43-50.

Ke-li WANG, J Hao and ZHAO Hong-yan, 2006. Advection and convergence of water vapor transport over the northwest China. 水科学进展, 17(2), 164-169.

Kotal BD, D Arpita and BK Choudhury, 2010. Genetic variability and association of characters in wheat (Triticum aestivum L.). Asian Journal of Crop Science, 2(3), 155-160.

Lal R, 2004. Soil carbon sequestration impacts on global climate change and food security. Science, 304(5677), 1623-1627.

Larik AS, 1979. Correlation and path coefficient analysis of yield components in mutant of triticum aestivum.

Lesk C, P Rowhani and N Ramankutty, 2016. Influence of extreme weather disasters on global crop production. Nature, 529(7584), 84-87.

Liwani U, LS Magwaza, AO Odindo and NJ Sithole, 2019. Growth, morphological and yield responses of irrigated wheat (Triticum aestivum L.) genotypes to water stress. Acta Agriculturae Scandinavica, Section B—Soil & Plant Science, 69(4), 369-376.

Lobell DB, W Schlenker and J Costa-Roberts, 2011. Climate trends and global crop production since 1980. Science, 333(6042), 616-620.

Manickavelu A, N Nadarajan, SK Ganesh, RP Gnanamalar and R Chandra Babu, 2006. Drought tolerance in rice: morphological and molecular genetic consideration. Plant Growth Regulation, 50(2), 121138.

McKersie B, 2015. Planning for food security in a changing climate. Journal of Experimental Botany, 66(12), 3435-3450.

Mohammadi-joo S, A Mirasi, R Saeidi-Aboeshaghi and M Amiri, 2015. Evaluation of bread wheat (Triticum aestivum L.) genotypes based on resistance indices under field conditions. International Journal Bioscience, *6*(2), 331-337.

Monneveux P, R Jing and SC Misra, 2012. Phenotyping for drought adaptation in wheat using physiological traits. Frontiers in Physiology, 3, 429.

Naserian B, AA Asadi, M Rahimi and MR Ardakani, 2007. Evaluation of wheat cultivars and mutants for morphological and yield traits and comparing of yield components under irrigated and rain fed conditions. Asian Journal of Plant Sciences.

Nonami H, 1998. Plant water relations and control of cell elongation at low water potentials. Journal of Plant Research, 111(3), 373-382.

Okçu G, MD Kaya and M Atak, 2005. Effects of salt and drought stresses on germination and seedling growth of pea (Pisum sativum L.). Turkish Journal of Agriculture and Forestry, 29(4), 237-242.

Rucker KS, CK Kvien, CC Holbrook and JE Hook, 1995. Identification of peanut genotypes with improved drought avoidance traits. Peanut Science, 22(1), 14-18.

Sen C and B Toms, 2007. Character association and component analysis in wheat (Triticum aestivum L.). Crop RESEARCH-HISAR-, 34(1/3), 166.

Shewry PR, 2009. Wheat. Journal of Experimental Botany, 60(6), 1537-1553.

Steel RGD and JH Torrie, 1997. *Principles and procedures of statistics, a biometrical approach* (No. Ed. 2). McGraw-Hill Kogakusha, Ltd.

Slafer GA and FH Andrade, 1991. Changes in physiological attributes of the dry matter economy of bread wheat (Triticum aestivum) through genetic improvement of grain yield potential at different regions of the world. Euphytica, 58(1), 37-49.

Smoček J, 1977. Path and correlation analysis of winter wheat plant productivity. Cereal Research Communications, 439-449.

Taiz L and E Zeiger, 2006. Stress physiology. Plant Physiol. 4.

Velikova V, I Yordanov and A Edreva, 2000. Oxidative stress and some antioxidant systems in acid raintreated bean plants: protective role of exogenous polyamines. Plant Science, 151(1), 59-66.

Wang S, ZI Xu, RS Xie and ZH Zhang, 1991. Comparison on the inheritance of main traits in wheat grown in south and north areas. Acta Agricultural University, 125-133.

Yoshida Y, K Nagakane, R Fukuda, Y Nakayama, M Okazaki, H Shintani and B Van Meerbeek, 2004. Comparative study on adhesive performance of functional monomers. Journal of Dental Research, 83(6), 454-458.

Zaheer A and Z Ahmad, 1991. Co-heritability among yield and yield components in wheat. Sarhad Journal Agriculture, 7(1), 65-67.

Zeid IM and ZA Shedeed, 2006. Response of alfalfa to putrescine treatment under drought stress. Biologia Plantarum, 50(4), 635-640.