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Investigating drought tolerance potential of different Wheat (*Triticum aestivum* L.) varieties under reduced irrigation level

Muhammad Aown Sammar Raza[*1], Muhammad Saqlain Zaheer[1], Muhammad Farrukh Saleem[2], Imran Haider Khan[2], Farhan Khalid[1], Muhammad Usman Bashir[1], Muhammad Awais[1], Rashid Iqbal[1], Salman Ahmad[1], Muhammad Usman Aslam[1], Imran Haider[1]

[1]*Department of Agronomy, The Islamia University of Bahawalpur, Bahawalpur, Pakistan*

[2]*Department of Agronomy, University of Agriculture, Faisalabad, Pakistan*

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Abstract

Drought stress is one of the main abiotic stresses that eventually lead to a drastic reduction in the final yield of wheat crop throughout the world. Identification of the drought resistant or drought susceptible wheat variety becomes an essential approach to improve crop production on sustainable basis. A planned study was conducted to evaluate the tolerance potential of ten wheat varieties (Aas-211, Mairaj-2008, Fareed-2006, Punjab-2011, Lasani-2008, Faisalabad-2008, Galaxy-2013, Millat-2011, AARI-2011 and auqab-2000) under drought stress conditions at different growth stages (To= Control, T_1= Drought at tillering stage, T_2= Drought at anthesis stage, T_3= Drought at grain filling stage). Results revealed that yield and yield related parameters significantly differed among all genotypes of wheat under drought stress condition. 10.45%, 25.15% and 48.45% reduction of grain yield per plant was noticed when drought occurred at tillering, anthesis and grain filling stage respectively. Drought occurs at grain filling stage cause maximum reduction of grain yield. Galaxy-2013 and Punjab-2011 were recorded the highest yielding varieties among them under drought at different growth stages. Lasani-2008 was selected as most drought resistant variety and Auqab-2000 selected as most drought sensitive variety.

* **Corresponding Author:** Muhammad Aown Sammar Raza ✉ aown_samar@yahoo.com

Introduction

Less rainfall is the main constraint for wheat production in the arid/ semi-arid regions, reducing 50% crop yield (Wang *et al*., 2003). Drought stress negatively effect on the growth and development of crop, result in the decrease of crop productivity (Kamal *et al*., 2010). During plant life cycle, soil and atmospheric water deficiency is an emerging future scenario of enhancing arid climate regions due to the global warming (Varallyay, 2010). Plant response to water stress is very complex that may be adoptive or detrimental. Water stress can be managed by avoidance or tolerance strategies which vary with crop genotype. Metabolic and structural capabilities of a plant under drought stress condition can be modified by gene expression that improves their potential under stress condition (Atkinson and Urwin, 2012).

Different stimuli are generated during stress environment in the leaf and roots to alter the physiological and biochemical processes in plants (Klamkowski *et al*., 2015). Drought stress impact on plants varies with the growth stages, duration, intensity and frequency of drought. Water deficient condition effects the seed germination which is highly sensitive to drought (Ali *et al*., 2007). Low moisture availability at critical growth stage of the plant is the major growth reduction factor in semiarid and arid regions. Seedling establishment is a major indicator to determine crop development and maturity under stressful condition (Rauf *et al*., 2012). Mass flow and mineral nutrients diffusion significantly reduced by soil moisture or osmotic potential that cause the reduction in the availability of soil nutrients to plant roots which ultimately cause of diminishing crop yield (Oliveira *et al*., 2010).

Drought stress is the main threat for reduction of crop growth and yield. Identification of drought resistant wheat cultivar is very necessary for feeding increasing population during drought conditions (Baligar *et al*., 2001; Ahmad *et al*., 2014). The present study planned to screen drought tolerant wheat variety on the basis of performance of growth and yield related parameters under drought stress.

Materials and methods

A wire house experiment was carried out during 2015-16 in pots at Department of agronomy, University College of Agriculture and Environmental Sciences IUB for the Screening of wheat cultivars under drought stress conditions. Ten wheat varieties (Aas-211, Mairaj-2008, Fareed-2006, Punjab-2011, Lasani-2008, Faisalabad-2008, Galaxy-2013, Millat-2011, AARI-2011, Auqab-2000) were sown in pots. Drought induction schedules viz., T_0 (Control), T_1 (Drought at tillering stage), T_2 (Drought at anthesis stage), T_3 (Drought at grain filling stage). Physicochemical analysis of the soil, used for experiment shows that it contained: sand 21%, silt 15%, clay 64%, organic matter 0.81%, nitrogen 0.31 (mg kg^{-1} dry soil), phosphorous 4.7 (mg kg^{-1} dry soil), potassium 127 (mg kg^{-1} dry soil), calcium 102 (mg kg^{-1} dry soil) and soil pH was 7.6. Each pot contains 8 kg dry soil and ten seeds were sown in it. Germinated seeds counted daily for ten days up to completion germination. When seed radical obtained 2 mm of length it is considered to be germinate. Germination percentage was calculated by following formula;

Germination (%) = (Germinated seed/total seed) × 100.

After 22 days of germination, three plants were left and others were thinned out. Water stress created according to the treatments by withholding irrigation at different growth stages. Experiment was conducted by Randomize complete block design with factorial arrangement having three replications. Different growth and yield related parameters such as plant height, spike length, number of spikelets per spike, number of grains per spike, 1000 grain weight and grain yield per plant were measured by using different standard procedures.

Collected data was analyzed by using fisher's analysis of variance technique by using the software Statistic 8.1 and LSD test at 5% probability was used to compare the differences among treatments (Steel *et al*., 1997).

Results

Germination (%)

Data regarding to germination percentage under control condition shown in Fig. 1. was significantly affected in different wheat varieties. Maximum Germination (%) was observed in Galaxy-2013 (85.23%) and Punjab-2011(84.43%) and lowest was observed in Millat-2011(40.5%).

Plant height (cm)

Data regarding to plant height (Table 1) showed that plant height significantly affected in different wheat varieties. It was observed that maximum plant height was noticed in Aas-2011 (96.03cm) followed by AARI-2011 (95.01cm) and lowest was noticed in Millat-2011 (85.90 cm). Plant height was also significantly affected when drought occurred at different growth stages.

Table 1. Effect of different growth stages water stress, on plant height (cm) of different wheat varieties.

Treatments	D_0 (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	99.60 a	89.21 lmn	96.27 b	99.06 a	96.03 a
V_2 (Mairaj-2008)	91.56 ghi	82.13 st	88.33 mn	91.03 hij	88.26 f
V_3 (Fareed-2006)	93.53 def	84.39 qr	90.30 ijkl	93.00 efg	90.30 d
V_4 (Punjab-2011)	91.00 hijk	81.18 t	85.97 pq	89.37 klm	86.88 g
V_5 (Lasani-2008)	91.46 ghi	82.10 st	88.29 mn	91.04 hij	88.22 f
V_6 (Faisalabad-2008)	93.43 ef	86.02 p	92.32 fgh	93.00 efg	91.19 c
V_7 (Galaxy-2013)	90.40 ijk	86.12 op	90.00 ijkl	90.05 ijkl	89.14 e
V_8 (Millat-2011)	90.66 hijkl	79.25 u	86.01 pq	87.68 no	85.90 h
V_9 (AARI-2011)	95.46 bc	94.30 cde	95.13 bcd	95.13 bcd	95.01 b
V_{10} (Auqab-2000)	89.66 jklm	83.53 rs	85.39 pq	88.09 mn	86.67 gh
Mean	92.68 a	84.82 d	89.80 b	91.74 c	

Maximum plant height (90.66 cm) was observed in control condition and lowest (79.25 cm) noticed when drought occurred at tillering stage.

It was observed that when drought applied at different growth stages in different wheat varieties, maximum plant height observed in Aas-2011 (99.60 cm) and it was statistically affected when drought applied at grain filling stage. Lowest plant height was observed in Millat-2011 (79.25 cm) when drought occurred at tillering stage.

Table 2. Effect of different growth stages water stress, on spike length (cm) of different wheat varieties.

Treatments	D_0 (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	13.06 a	8.24 hijklmn	8.41 ghijklmn	9.89 cdefg	9.90 a
V_2 (Mairaj-2008)	10.96 cd	7.91 jklmn	7.73 klmn	8.93 fghijkl	8.88 bcd
V_3 (Fareed-2006)	11.20 bc	8.53 ghijklm	8.53 ghijklm	9.63 defghi	9.47 ab
V_4 (Punjab-2011)	12.60 ab	8.54 ghijklm	8.43 ghijklmn	10.10 cdef	9.91a
V_5 (Lasani-2008)	10.76 cd	9.06 efghijk	9.13 efghij	9.03 fghijkl	9.50 ab
V_6 (Faisalabad-2008)	9.766 defgh	7.55 lmn	7.12 mn	8.33 hijklmn	8.19 de
V_7 (Galaxy-2013)	12.66 a	8.29 hijklmn	8.92 fghijkl	10.10 cdef	9.99 a
V_8 (Millat-2011)	10.60 cde	7.79 jklmn	7.70 klmn	8.66 ghijklm	8.69 cde
V_9 (AARI-2011)	11.20 bc	8.15 ijklmn	8.50 ghijklm	8.00 jklmn	8.97 bc
V_{10} (Auqab-2000)	9.96 cdefg	6.97 n	7.34 mn	8.00 jklmn	8.07 e
Mean	11.28 a	8.12 c	8.09 c	9.06 b	

Spike Length (cm)

Crop yield potential can be determined from its spike length; data regarding spike length (Table 2.) shows more number of grains per spike is the result of greater spike length. Data regarding to spike length was analyzed and showed significant results. Maximum spike length was observed in Galaxy-2013 (9.99 cm) followed by Punjab-2011 (9.91cm) and lowest spike length was noticed in Auqab-2000 (8.07 cm). Spike length data shows that spike length was badly affected by drought. Maximum spike length (11.28 cm) was observed in control condition when no drought occur at any stage followed by when drought occurred at grain filling stage (9.06 cm) and smallest (8.09 cm) spike length was noticed when drought occur at anthesis stage. It was also noticed that spike length of Lasani-2008 was less affected by drought. Auqab-2000 showed less (6.97 cm) spike length when drought occurred at tillering stage. In control condition maximum plant height was observed in Aas-2011 (13.06 cm).

Table 3. Effect of different growth stages water stress, on number of spikelets per spike of different wheat varieties.

Treatments	Do (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	23.27 a	21.41 def	17.06 lm	19.68 ij	20.35 b
V_2 (Mairaj-2008)	22.77 abc	21.26 defg	17.13 lm	20.00 ghij	20.29 b
V_3 (Fareed-2006)	23.27 a	21.17 defgh	17.00 m	19.33 ijk	20.19 b
V_4 (Punjab-2011)	23.61 a	21.49 cde	17.30 lm	20.13 fghij	20.63 b
V_5 (Lasani-2008)	23.12 a	23.00 ab	21.70 bcd	20.00 ghij	21.95 a
V_6 (Faisalabad-2008)	23.13 a	19.96 hij	16.30 mn	18.33 hij	19.43 cd
V_7 (Galaxy-2013)	23.94 a	20.63 defghi	16.66 m	20.30 efghi	20.38 b
V_8 (Millat-2011)	22.74 abc	20.63 defghi	16.63 m	20.00 ghij	20.00 bc
V_9 (AARI-2011)	23.05 a	20.34 efghi	17.23 lm	20.06 ghij	20.17 b
V_{10} (Auqab-2000)	23.03 a	19.66 ij	15.30 n	19.00 jk	19.25 d
Mean	23.19 a	20.95 b	17.23 d	19.68 c	

Number of spikelets per spike

Number of spikelets per spike (Table 3) is an important growth parameter that shows the potential of a crop. Water stress adversely affects the number of spikelets per spike. Lowest (17.23) number of spikelets per spike was observed when drought occurred at anthesis stage and maximum (23.19) was noticed in control condition when no drought occurred at any stage. Data regarding number of spikelets per spike also showed that different varieties significantly affect the spikelets per spike.

Table 4. Effect of different growth stages water stress, on number of grains per spike of different wheat varieties.

Treatments	D_0 (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	27.63 c	23.48 klm	19.37 st	24.00 ijk	23.62 d
V_2 (Mairaj-2008)	27.41 c	23.34 lm	19.27 t	23.82 jkl	23.46 d
V_3 (Fareed-2006)	25.00 fgh	21.28 op	17.56 u	21.75 no	21.40 e
V_4 (Punjab-2011)	29.26 a	24.84 fgh	20.48 qr	25.40 ef	24.99 b
V_5 (Lasani-2008)	22.00 n	21.93 no	19.33 st	21.91 no	21.29 ef
V_6 (Faisalabad-2008)	26.10 d	20.00 rs	17.00 u	21.00 pq	21.03 f
V_7 (Galaxy-2013)	29.73 a	25.24 efg	20.73 pq	25.84 de	25.38 a
V_8 (Millat-2011)	23.00 m	19.51 st	16.16 v	20.00 rs	19.67 g
V_9 (AARI-2011)	28.36 b	24.01 ijk	19.87 rst	24.64 ghi	24.22 c
V_{10} (Auqab-2000)	24.50 hij	20.84 pq	17.18 u	21.37 nop	20.97 f
Mean	26.30 a	22.45 c	18.69 d	22.97 b	

Maximum number of spikelets per spike (21.95) noticed in Lasani-2008 followed by Punjab-2011(20.63) and lowest number of spikelets per spike (19.25) noticed in Auqab-2000. It was also observed that in control condition when no drought occurred at any stage maximum (23.94) number of spikelets per spike noticed in Galaxy-2013 and lowest (22.74) in Millat-2011. It was also noticed that Lasani-2008 is less affected by water stress when drought occurred at tillering, anthesis and grain filling stage.

Table 5. Effect of different growth stages water stress, on 1000-grain (g) weight of different wheat varieties.

Treatments	D_0 (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	39.70 bc	38.50 d	32.14 kl	26.53 qr	34.22 b
V_2 (Mairaj-2008)	38.80 d	37.61 e	31.47 l	25.99 r	33.47 c
V_3 (Fareed-2006)	36.73 fg	35.53 hi	29.70 m	24.52 s	31.62 d
V_4 (Punjab-2011)	41.26 a	39.98 b	33.35 j	27.66 op	35.57 a
V_5 (Lasani-2008)	35.00 i	33.98 j	28.35 no	23.48 tu	30.20 f
V_6 (Faisalabad-2008)	37.24 ef	36.03 gh	27.13 pq	23.10 u	30.87 e
V_7 (Galaxy-2013)	41.20 a	39.98 b	32.35 k	27.66 op	35.30 a
V_8 (Millat-2011)	35.96 gh	34.87 i	29.03 mn	24.02 st	30.97 e
V_9 (AARI-2011)	40.00 b	38.83 cd	32.40 k	26.86 pqr	34.52 b
V_{10} (Auqab-2000)	36.10 gh	35.01 i	27.23 pq	23.37 tu	30.42 f
Mean	38.20 a	37.03 b	30.32 c	25.32 d	

Number of grains per spike

Number of grains per spike (Table 4) has a vital role in the crop yield potential. Economical yield of crop was affected by the number of grains per spike. Data regarding number of grains per spike showed that maximum number of grains per spike was observed in Galaxy-2013 (25.35) followed by Punjab-2011(24.99) and lowest number of grains per spike (19.67) noticed in Millat-2011. Number of grains per spike also significantly affected by the drought stress at different growth stages. Highest number of grains per spike (26.30) was observed in control condition and lowest number of grains per spike (18.69) was noticed when drought occurred at anthesis stage. It was also observed that Lasani-2008 shows less effected by drought stress.

Table 6. Effect of different growth stages water stress, on grain yield per plant (g) of different wheat varieties.

Treatments	D_0 (Control)	D_1 (Drought at tillering stage)	D_2 (Drought at anthesis stage)	D_3 (Drought at grain filling stage)	Mean
V_1 (Aas-2011)	1.181 c	1.062 f	0.885 l	0.590 u	0.929 c
V_2 (Mairaj-2008)	1.182 c	1.062 f	0.885 l	0.590 u	0.929 c
V_3 (Fareed-2006)	1.061 f	0.954 h	0.795 o	0.530 v	0.835 e
V_4 (Punjab-2011)	1.252 a	1.125 d	0.937 i	0.625 s	0.984 a
V_5 (Lasani-2008)	0.891 l	0.890 l	0.840 m	0.800 o	0.855 d
V_6 (Faisalabad-2008)	1.132 d	0.910 k	0.690 q	0.410 y	0.785 g
V_7 (Galaxy-2013)	1.251 a	1.125 d	0.937 i	0.625 s	0.984 a
V_8 (Millat-2011)	0.920 j	0.811 n	0.675 r	0.450 x	0.714 h
V_9 (AARI-2011)	1.211 b	1.089 e	0.907 k	0.605 t	0.953 b
V_{10} (Auqab-2000)	1.013 g	0.907 k	0.750 p	0.500 w	0.792 f
Mean	1.109 a	0.993 b	0.830 c	0.572 d	

1000-Grain weight (g)

Data regarding 1000-grain weight (Table 5) was significantly affected in different wheat cultivars. Maximum 1000-grain weight (35.30 g) was noticed in Galaxy-2013 followed by Punjab-2011 (35.57 g) and lowest 1000-grain weight was observed in Lasani-2008 (30.20 g). In the interaction of drought and different wheat varieties maximum (41.20 g) 1000-grain weight was noticed in Galaxy-2013 under control condition when no drought occurred at any stage and lowest (23.10 g) observed in Faisalabad-2008 when drought occurred at grain filling stage. Drought stress significantly affected the

1000-grain weight, maximum 1000-grain weight (38.20 g) was observed in control condition when no drought occur at any stage followed by when drought occurred at tillering stage (37.03 g) and lowest 1000-grain weight noticed when drought occurred at grain filling stage (25.32 g).

Grain yield per plant

Final grain yield per plant is the combined effect of many yield related parameters and particular set of environmental condition. Grain yield per plant was significantly affected by the different wheat varieties (Table 6). Maximum grain yield per plant (0.984 g) was observed in Galaxy-2013 and Punjab-2011followed by AARI-2011 (0.953 g) and lowest grain yield per plant (0.714 g) was noticed in Millat-2011. Drought stress also significantly affected on grain yield per plant. Maximum grain yield per plant (1.109 g) was observed in control condition when no drought was occurred at any stage and lowest grain yield per plant (0.572 g) was noticed when drought occurs at grain filling stage. It was also observed that Lasani-2008 less affected by the drought stress.

Discussion

Water stress affects significantly to the crop growth and development by affecting physiological and biochemical processes. Negative effect of water stress can be reduced by partial closure of stomata or by increased penetration in of roots in soil profile (Blum *et al.*, 1980). Alfredo and Setter (2000) and Hoad *et al.* (2001) also reported same findings. Germination percentage is an important parameter to determine the germination potential of a crop seed. Galaxy-2013 and Punjab-2011 have the highest germination percentage as compare to the other varieties and Millat-2011 has the lowest germination percentage. Different wheat varieties have the different germination percentage that is due to their genetic makeup or it may be due to the external environment of the crop (Raza *et al.*, 2012).

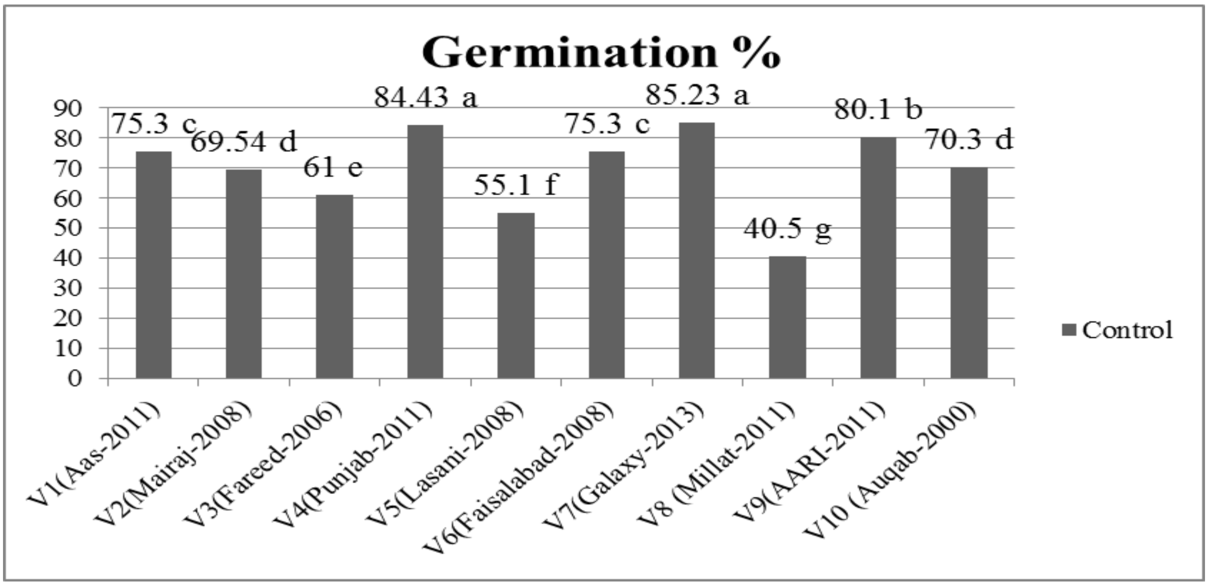

Fig. 1. Germination percentage of different wheat varieties under control condition.

Plant height is an important growth parameter that effect on the biological yield of the crop. Under drought stress plant height decreased due to the low turgidity of the cell and protoplasm dehydration. Hussain *et al.* (2008) reported that less turgidity and dehydration of the protoplasm is directly related with the cell division. Plant height varies with different cultivars (Shirazi *et al.*, 2014). Plant height is severely affected when drought occurs at tillering stage.

Maximum plant height observed in control condition when no drought occurs at any stage and lowest when drought occurs at tillering stage (Raza *et al.*, 2012). Due to the water stress, hormonal balance is affected in plant that can decrease the plant growth (Zhao *et al.*, 2006). 8.48% decrease in plant height was observed when drought occurs at tillering stage as compared to the control condition when no drought occurred at any growth stage.

Maximum plant height was observed in Aas-2011(96.03cm). Non-significant difference was noticed in Aas-2011, when drought occurs at grain filling stage to the controlled treatment. Maximum plant height was noticed in Aas-2011 (99.60 cm) followed ARRI-2011 (95.46 cm), Fareed-2006 (93.53 cm), Faisalabad-2008 (93.43 cm) and lowest in Millat-2011 (85.90 cm). Different wheat genotypes showed different plant height and severely affected when drought occurred at any stage (Ihsan *et al.*, 2015).

Spike length has important contribution to the final crop yield, it effects on the number of spikelets per spike, grain size and number of grains per spike. More spike length leads to more number of spikelets per spike which leads to more number of grains and then ultimately the maximum crop yield. Drought stress severely effects on spike length (Ihsan *et al.*, 2015). Maximum spike length (11.28 cm) was noticed when no drought occurred at any stage. Lowest spike length (8.09 cm) was noticed when drought occurred at anthesis stage that is 28.28% less than the normal irrigation. 28.01% and 19.68% decrease spike length was noticed when drought occurred at tillering and grain filling stage respectively, these results showed same with findings of Aown *et al.* (2012). Different genotype of wheat showed different spike length (Ihsan *et al.*, 2015), maximum spike length (9.99 cm) was noticed in Galaxy-2013 followed by Punjab-2011 (9.91 cm), Aas-2011 (9.90 cm), Lasani-2008 (9.50 cm), Fareed-2006 (9.47 cm) and lowest was noticed in Auqab-2000 (8.07 cm). It was observed that spike length of Lasani-2008 in less effected by the drought stress and same finding was noticed by Raza *et al.* (2012) that Lasani-2008 is the most resistant to drought stress. Under control condition Maximum spike length was observed in Aas-2011 (13.06 cm) and Galaxy-2013 (12.66 cm). Lasani-2008 showed 10.76 cm spike length under control condition and 9.06 cm, 9.13 cm, 9.03 cm when drought occur at tillering, anthesis and grain filling stage respectively. Under drought stress Lasani-2008 showed more spike length as compare to the other cultivars.

Number of spikelets per spike contributes to the total economic yield of the crop. Highest (23.19) number of spikelets per spike was noticed when no drought occurred at any growth stage. 9.65%, 25.70% and 15.13% decreased in crop yield was observed when drought occurred at tillering, anthesis and grain filling stages respectively. Number of spikelets per spike decreased when drought occurred at anthesis stage (Aown *et al.*, 2012). Number of spikelets per spike was noticed in Galaxy-2013 (23.94) under control treatment and lowest (22.77) was observed in Mairaj-2008. Lasani-2008 was less affected when drought occurred at different growth stages. Lowest number of spikelets per spike was observed in Auqab-200 (15.30) when drought occurred at anthesis stage. Numbers of grains per spike adversely decrease under water stress (Richards *et al.*, 2001). Dencic *et al.* (2000) reported that flowering stage is the most sensitive stage to water stress and decreased the number of grains per spike'.

Number of grains per spike is the most important yield parameter that highly affects the crop yield. Plant breeders pay more attention to the number of grains per spike while selecting the genotype for higher production. Maximum number of grains per spike was noticed when no water stress occurred at any growth stage and lowest number of grains per spike was observed when drought occurred at anthesis stage (Aown *et al.*, 2012). 14.63%, 28.93% and 12.66% decrease in number of grains per spike noticed when drought occurred at tillering, anthesis and grain filling stages respectably. Nawaz *et al.* (2015) reported that different wheat cultivars showed different number of grain per spike due to their genotypic makeup. Maximum number of grains per spike (25.38) was noticed in Galaxy-2013 followed by Punjab-2011 (24.99), AARI-2011 (24.22), Aas-2011 (23.62), Mairaj-2008 (23.46) and lowest was observed in Millat-2011 (19.67). Lasani-2008 was not statistically affected when drought occurred at tillering, anthesis and grain filling stage.

1000-grain weight is an important yield parameter that plays an important role in the actual yield of the crop. Maximum 1000-grain weight was noticed under control treatment when no drought occurred at any stage followed by when drought occurred at tillering (37.03 g), anthesis (30.32 g) and grain filling stage (25.32 g) respectively. It was observed that 3.03%, 20.62%, and 33.31% yield reduced when drought occur at tillering, anthesis and grain filling stage respectively. These results are same with the results of Aown *et al.* (2012).

Khakwani *et al.* (2012) was also reported that crop yield decrease under drought stress. Different genotypes of wheat cultivars showed different 1000-grain weight due to their genetic characteristics. Maximum 1000-grain weight (41.26 g) was noticed in Punjab-2011, Galaxy-2013 (41.20) followed by AARI-2011 (40 g), Aas-2011 (39.70 g), Mairaj-2008 (38.80 g), Fasilabad-2008 (37.24 g) and lowest was observed in Lasani-2008 (35.00 g) under control treatment. When drought occurred at grain filling stage lowest 1000-grain weight noticed in Faisalabad-2008 (23.10 g).

Grain yield per plant is the main and actual focusing point for the researchers. About 10.45%, 25.15% and 48.45% reduction of grain yield per plant was noticed when drought occurred at tillering, anthesis and grain filling stage respectively. Maximum grain yield per plant was reduced when drought occurred at grain filling stage (Aown *et al.*, 2012).

It was observed that Galaxy-2013 and Punjab-2011 was the highest yield producing crop cultivars as compare to the others. It was also noticed that under control treatments Lasani-2008 (0.891 g) was less yield producing variety as compared to others. It was also noticed that statistically Lasani-2008 less affected by the drought stress as compared to others. When drought occurs at grain filling stage Faisalabad-2008 (0.410 g) was most affected. Different wheat genotypes show different yield characteristics under drought stress (Ihsan *et al.*, 2015).

Conclusion

Drought resistant cultivars development is a laborious job with conventional breeding, it also need a sufficient time and capital. Screening of already cultivated wheat varieties under drought stress condition is the solution of the problem. Among all ten tested wheat cultivars, Galaxy-2013 and Punjab-2011 were recorded the highest yielding varieties among them under drought. Lasani-2008 was selected as most drought resistant variety and Auqab-2000 selected as most drought sensitive variety. Thus, these wheat cultivars recommended for general cultivation.

Moreover, when drought stress occur at different growth stages it cause reduction of crop yield, but drought occur at grain filling stage cause maximum reduction of grain yield. Genetic bases of wheat cultivars can be used to develop drought resistant varieties.

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