Bangladesh J. Bot. **50**(2): 235-243, 2021 (June)

IMPACT OF IRRIGATION ON YIELD ATTRIBUTES OF SEVEN WHEAT GENOTYPES

MURAD ALI*, ZIA ULLAH[1], MUHAMMAD SAEED, AHMAD ZUBAIR, ANSAAR AHMED[2] AND BILAL AHMAD

Cereal Crops Research Institute, Pirsabak, Nowshera, Pakistan

Keywords: Yield attributes, Wheat genotypes, Impact of irrigation

Abstract

Seven wheat genotypes i.e., PR-110, PR-112, PR-115, PR-118, PR-119, PR-120 and Pirsabak-13 were evaluated at: I_0: Control, I_1: irrigation at seedling stage, I_2: irrigation at seedling and booting stages, I_3: irrigation at seedling, tillering and booting stages and I_4: irrigation at seedling, tillering, booting and grain formation stages. Among the genotypes, PR-115, PR-118 and PR-120 were found to be superior for grain yield and its related attributes under full and deficit water conditions. Irrigation at seedling + tillering + booting stages + grain formation stages (I_4) produced statistically higher yield and related traits. It was also observed that in case of water shortage, irrigation at seedling and booting stages reduced the drastic losses in grain yield of wheat. The study suggested that identified promising wheat genotypes can be utilized in future breeding programs to develop drought tolerant varieties.

Introduction

Today agriculture sector is confronting the challenges of more food production due to increase in population, urbanization and limiting resources (Liu *et al*. 2007). About 37% of wheat growing areas in developing countries is semi-arid and face severe water scarcity problem (Karousakis and Koundouri 2006). Environmental stresses like drought, salinity, terminal heat stress and diseases have highly affected wheat production (Rebetzke and Richards 1999, Reynolds *et al*. 1999, Bux *et al.* 2013). Water scarcity is an alarming situation in the recent past and have become a risk to the production of wheat and other crops as well as water resources itself in developing countries (Rogers and Lydon 1994). About 3.3 million acre feet of water scarcity have been estimated in Pakistan during Rabi seasons (GOP 2014). Due to climate change fluctuations in rainfall make the situation very worst. Wheat yield sustainability highly depends on availability of water. To cope with the issue of water shortage, two approaches i.e. engineering based approach (construction of water reservoirs) and agronomy based approach (on farm water management) are utilized. In agronomic based approach, crops have to be sown with less water requirements or apply minimum amount of water. Regulated deficit irrigation might be a solution to obtain more crops per drop of water (Al-Harbi *et al*. 2015, Allahverdiyev *et al.* 2015). It helps to decrease water consumption and lessen sever effects on production. Irrigating the crop only at drought sensitive growth stages and withheld water at other stages can help to manage water resources to meet crop requirement (Du *et al*. 2010). Additional irrigated area with the saved water might compensate the yield reduction due to deficit irrigation. Ali *et al.* (2007) identified the stages tillering, stem elongation, booting, and grain formation as moisture critical stage in wheat crop. Yield of crops under deficient water availability can be maximized by applying modern breeding techniques and knowing stress associated characters of plants (Strauss and Agenbag 2000, Li *et al*. 2013). Therefore, evaluation and selection of wheat germplasm under water stress condition are

*Author for correspondence: <muradses@gmail.com>. [1]University of Padova, Department of Agronomy, Food, Natural Resources, Animal and Environment (DAFNAE), Legnaro, Italy. [2]International Maize and Wheat Improvement Center, Cereal Crop Research Institute, Pirsabak, Nowshera, Pakistan.

DOI: https://doi.org/10.3329/bjb.v50i2.54078

the main breeding objectives (Albokari *et al.* 2016). Keeping in view that water scarcity is a critical issue particularly for developing countries current research was carried out with the objectives to screen newly developed wheat lines under the drought stress at different growth stages, to identify potential wheat lines based on drought tolerance for economic traits and utilization of superior wheat lines in future breeding programs.

Materials and Methods

A field experiment was conducted at Cereal Crops Research Institute, Pirsabak Nowshera (34^0 N latitude, 72^0 E longitude) Khyber Pakhtunkhwa, Pakistan. Before conducting the experiment, soil was analyzed for its physicochemical properties and soil texture was found silty loam having 0.82% organic matter, 4.2 mg/kg available phosphorous, 70 mg/kg available potassium with 0.13 dS/m EC and 8.1 pH. A field was selected with a plot size 2×5 m^2. The experiment was arranged in RCB with spilt plot design and replicated thrice. The following treatments effect was studied I_0: Control (No irrigation), I_1: One irrigation (seedling stage), I_2: Two irrigation (seedling + booting stages), I_3: Three irrigation (seedling + tillering + booting stages), I_4: Four irrigation (seedling + tillering + booting stages + grain formation) on seven wheat genotypes included PR-110, PR-112, PR-115, PR-118, PR-119, PR-120 and Pirsabak-2013 (Check). The parentages of these genotypes are shown in Table 1. Numbers of irrigation was allotted to main and wheat lines to sub plot. Recommended dose (120-90-60 kg NPK/ha) of fertilizers was used (Shehzadi *et al.* 2017). The sources of NPK were urea, DAP and SOP, respectively. Nitrogen was applied in two splits, one at sowing time and other at seedling stage while phosphorous and potassium were applied at the time of seed bed preparation. The wheat lines were sown manually with hand drill @ 120 kg/ha. Mean monthly temperature, rainfall and stress duration was recorded during the growing season of wheat as presented in Table 2. The traits examined in this study were plant height, time of maturity, spike length, spikelet per spike, grains per spike, number of spikes/m^2, grain yield and biological yield according to standard procedure. Normal recommended cultural practices were followed throughout the growing session. The recorded data were statistically analyzed using ANOVA technique by using statistix 8.1 software. Interactions were drawn for different yield traits. Treatments differences were examined by using LSD with p at 0.05 and 0.01 probability levels (Steel *et al*. 1997).

Table 1. Parentage of the wheat genotypes.

Genotypes	Parentage
PR-110	KAUZ//ALTAR 84/AOS/3/MILAN/KAUZ/4/HUITES/7/ CAL/NH//H567.71/3/SERI/4/ CAL/NH//H567.71 /5/2*KAUZ/6/PASTOR
PR-112	YAV79//DACK/RABI/3/SNIPE/4/ AE. SQUARROSA (460….
PR-115	VORB/3/T.DICOCCON PI94625/AE.SQUARROSA (372)//3*PASTOR
PR-118	WBLL1*2/4/YACO/PBW65/3/KAUZ*2/TRAP//KAUZ*2/6/NG8201/KAUZ/4 /SHA7//PRL/VEE#6/3/FASAN/5/MILAN/KAUZ
PR-119	NAC/TH.AC//3*PVN/3/MIRLO/BUC/4/2*PASTOR/5/ KACHU/6/KACHU
PR-120	KISKADEE #1//KIRITATI/2*TRCH
PS-13	CS/TH.SC//3*PVN/3/MIRLO/BUC/4/MILAN/5/TILHI

Table 2. Distribution of rainfall, temperature and stress duration during the growing seasons.

Period	Temperature (ºC)		Rainfall (mm)	Stress duration (days)
	Max	Min		
Nov. 30 - Dec. 30	22	3.1	0.3	28
Jan. 1 - Jan. 31	16.8	4.1	79.02	19
Feb. 1 - Feb. 28	22.5	6	63.03	22
Mar. 1 - Mar. 31	25.9	9.8	20.04	23
April. 1 - April. 30	31.8	15.4	51.05	20
May. 1 - May. 30	36.8	21.3	36.04	21
Total			249.48	

Results and Discussion

The analysis of variance revealed that Irrigation schedules significantly ($p \leq 0.05$) affected plant height, days to maturity, number of productive spike/m^2 and spike length (Table 3). The highest plant height was noted in genotype PR-112 which was15.46% more than Pirsabak-13. The plot with four irrigations had greater plant height i.e. 11.11% than control. The interaction between irrigation schedules and genotypes was found significant regarding plant height (Fig. 1). The results of present research are in agreement with the findings of Baloch *et al.* (2014) who reported that irrigation availability statistically influenced plant height. The study further observed that despite of genotypes, plants grew maximally under four irrigation schedules and reducing irrigation levels adversely affected plant height. Irrigation applied at critical stages increased plant height of all genotypes which might be due to the variation in the genetic traits as well as sufficient availability of plant nutrients having no water deficit (Sarwar *et al.* 2010).

Table 3. Maturity duration and yield components of wheat genotypes as affected by irrigation schedules.

Treatment	Plant height (cm)	Days to maturity	Number of spikes/m^2	Spike length (cm)
Inbred lines (L)				
PR-110	107c	144a	313d	9.98ab
PR-112	112a	143ab	338b	9.78bcd
PR-115	105d	143b	349a	9.8bc
PR-118	105d	143a	344ab	10a
PR-119	109b	143b	329c	9.96ab
PR-120	108bc	143ab	324c	9.56d
PS-13	97e	139c	339b	9.62cd
$LSD_{(0.05)}$	1.4	0.75	8	0.21
Number of irrigations (I)				
No irrigation	99e	137d	272d	9.2c
One irrigation	105d	139c	329c	9.6b
Two irrigation	107c	143b	350b	10a
Three irrigation	109b	146a	353b	10a
Four irrigation	110a	147a	365a	10.1a
$LSD_{(0.05)}$	1.3	1.5	5	0.3
Line × Irrigation				
$LSD_{(0.05)}$	Fig. 1	Fig. 2	Fig. 3	Fig. 4

Mean values followed by similar letter are not significantly different from each others; PS-13: Pirsabak-13.

Genotype pirsabak-13 showed early maturity and took 3.59% less days as compared to genotypes PR-110 which took longer time in maturity and statistically at par with genotypes PR-118, PR-112 and PR-120. It was observed that pirsabak-13 could be recommended as early maturing genotypes. This finding is in agreement with the results of Onyibe (2005) who reported that irrigation at all growth stages enhanced time of maturity in wheat. Interaction between genotypes and irrigation schedules was also observed significant for days to maturity (Fig. 2). The probable reason of delayed maturity due to irrigation at all stages might be due to excessive uptake of nutrients and absence of abiotic stresses (Sarwar *et al.* 2010).

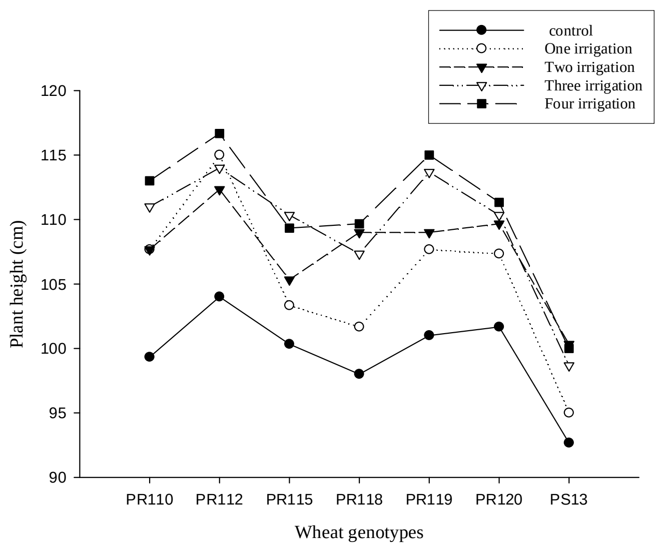

Fig.1. Plant height (cm) of wheat genotypes as influenced by irrigation levels.

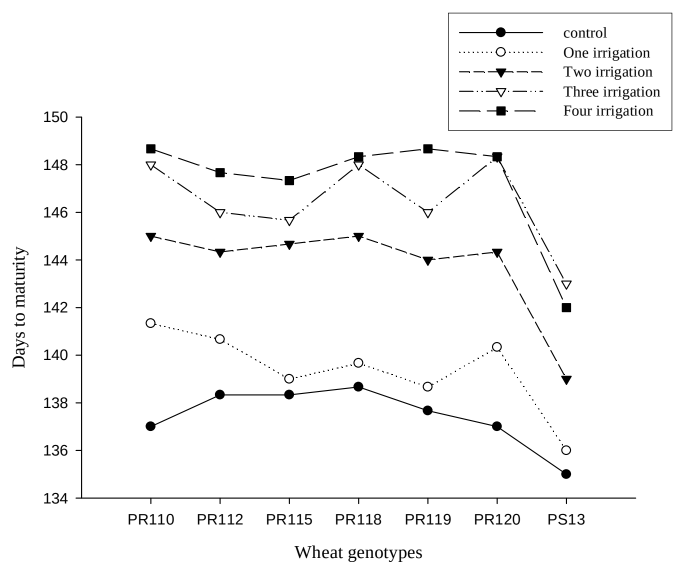

Fig. 2. Days to maturity of wheat genotypes as influenced by irrigation levels.

The genotypes PR-115 (11.5%) and PR-118 (9.9%) produced more number of spikes. In case of irrigation schedules genotypes showed significant response with higher productive spikes in treatment I_4 followed by treatment I_3 and I_2 while lower was noted in plot which was not irrigated throughout the growing season (I_0). Ngwako and Mashiqa (2013) concluded that spikes/m^2 of wheat cultivar effect with irrigation levels. Kabir *et al*. (2009) also reported that number of fertile spike decreases as the irrigation was not applied during vegetative period. Productive tillers significantly affect due to interaction of genotypes and irrigation schedules (Fig. 3). The credible cause of enhance number of spike/m^2 of all genotypes might be due to optimum availability of water during critical stage (Sarwar *et al*. 2010).

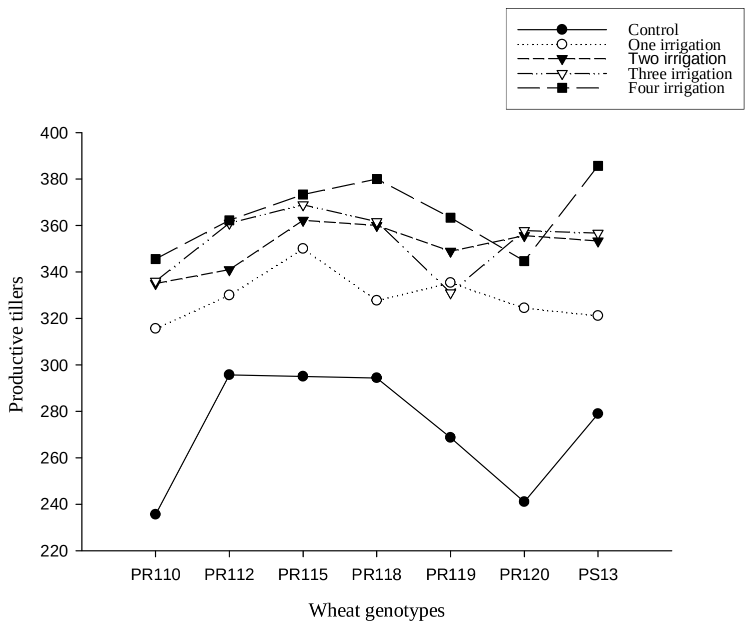

Fig. 3. Productive tillers/m^2 of wheat genotypes as influenced by irrigation levels.

That maximum spike length was measured in genotype PR-118 which was statistically uniform to PR-110. Wheat genotypes PR-118 produced 4.6% longer spike. In irrigation, treatment I_4 produced (9.7%) more spike length than control (I_0). Interaction between genotypes and irrigation schedules was found significant as shown in Fig. 4. Sarkar *et al*. (2017) reported that irrigation significantly enhanced spike length. Baloch *et al*. (2014) concluded that irrigation frequency significantly improved spike length and yield related traits.

Mean effect scored for number of spikelet per spike, grains per spike, biomass and grain yield was statistically significant among wheat genotypes and irrigation schedules. Significant interaction effects were recorded for biomass (Fig. 5) and grain yield (Fig. 6) whereas non-significant ($p \geq 0.05$) interactions were observed for spikelet per spike and grains per spike (Table 4). Maximum number of spikelet (6.3%) was counted in genotypes PR-115 and statistically at par with genotypes PR-110. In case of irrigation schedules, highest number of spikelet (15.2%) was recorded for treatment I_4. The optimum irrigation at reproductive stage increase spikelet per spike (Sarkar *et al.* 2017). Dencic *et al.* (2000) reported that water stress during critical growth stage reduced number of spikelet of wheat genotypes.

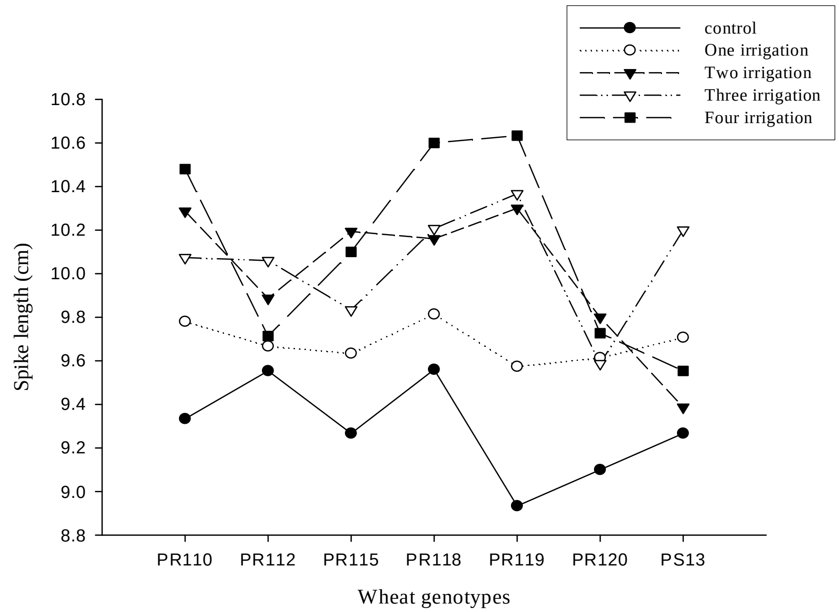

Fig. 4. Spike length (cm) of wheat genotypes as influenced by irrigation levels.

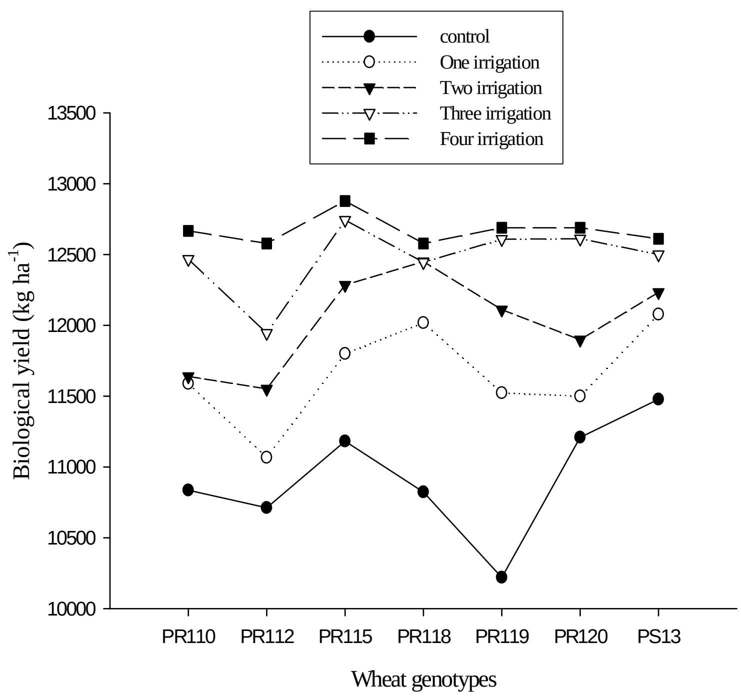

Fig. 5. Biological yield (kg/ha) of wheat genotypes as influenced by irrigation levels.

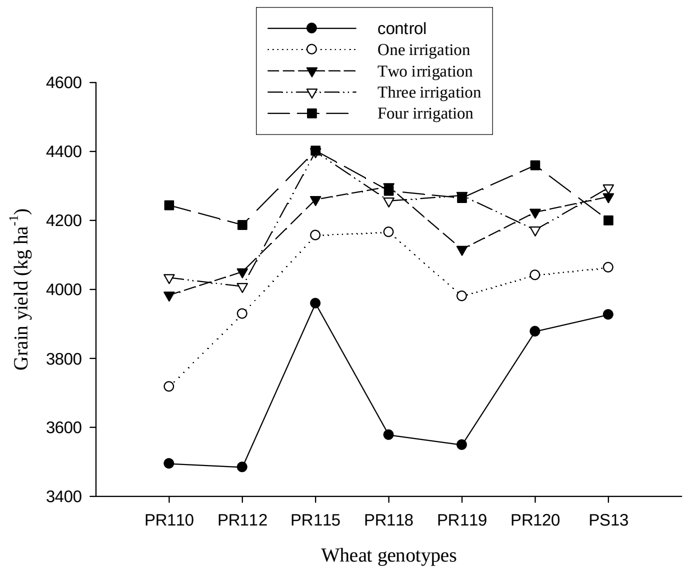

Fig. 6. Grain yield (kg/ha) of wheat genotypes as influenced by irrigation levels.

The maximum number of grains/spike (6.12%) was counted in genotypes PR-115 which is statistically identical to all genotypes except PR-110 and PR-119. The minimum values for grains/spike was recorded for PR-119 and PR-110 which is also statistically at par. In case of irrigation schedules the treatment I_4 proved to be more productive in number of grains/spike (12.7%) over control treatment. Dencic *et al*. (2000) concluded that grains/spike of different wheat genotypes were found more susceptible to water stress. These results are further corroborating with observations of Maqsood and Azam Ali (2007) studied that water deficit decreased number of seed per year in millet.

Genotypes PR-115, pirsabak-13, PR-118 and PR-120 produced significantly ($p \leq 0.05$) identical yield (Table 4). The analysis of the data revealed that irrigation levels during the vegetative period enhanced (16%) biological yield over no irrigation treatment. The plot which received four irrigations during their growing produced statistically higher biological yield, while lower was observed in control. Sarkar *et al.* (2017) quoted the generic results. Ibrahim *et al.* (2011) further supported the current findings and concluded that production enhanced due to irrigation as compared to deficit irrigation treatment. The findings of some researcher suggested that about 20% increase in grain yield was due to increased biological yield (Shahryari *et al.* 2011). Improving plant growth in irrigation treatment might be due to intercept of more solar radiation vs. non irrigated plot (Ngwako and Mashiqa 2013).

Irrigation levels enhanced grain yield, the genotype PR-115 produced highest (4235 kg/ha) while PR-110 produced lowest (3894 kg/ha) grain yield which is statistically uniform with PR-112. Treatment I_4 enhanced grain yield over the other treatments followed by the treatment I_2 and I_3 which is statistically identical. The results indicated that the treatment I_4 effect is significant for higher yield (4277 kg/ha) while the lower was observed in control (I_0). Kabir *et al*. (2009) and Ali *et al.* (2007) reported similar findings for wheat crop. Highest grain yield in genotype PR-115 might be due to the utmost number of fertile tiller/m^2, 1000-grain weight and number of grains/spike (Khokhar *et al.* 2010). Irrigation applied at crown root stage enhanced fertile tiller, while at booting stage improved number of spikelet/spike and grains/spike (Khokhar *et al*. 2010).

Table 4. Yield and yield components of wheat genotypes as affected by irrigation schedules.

Treatment	Spikelet/ spike	Number of grains/spike	Biological yield (kg/ha)	Grain yield (kg/ha)
Inbred lines (L)				
PR-110	18.3a	50bc	11839bc	3894d
PR-112	17.4b	51ab	11570d	3931d
PR-115	18.5a	52a	12177a	4235a
PR-118	17.6b	51ab	12062ab	4116b
PR-119	17.4b	49c	11830c	4036c
PR-120	17.4b	50abc	11981abc	4134b
PS-13	17.6b	51ab	12180a	4150b
LSD $_{(0.05)}$	0.64	1.7	224	66
Number of irrigations (I)				
No irrigation	16.4d	47c	10922e	3695d
One irrigation	17.3c	50bc	11653d	4007c
Two irrigation	18bc	52ab	12023c	4171b
Three irrigation	18.1b	52ab	12474b	4205b
Four irrigation	18.9a	53a	12670a	4277a
LSD $_{(0.05)}$	0.74	2	156	44
Line × Irrigation				
LSD $_{(0.05)}$	NS	NS	Fig. 5	Fig. 6

NS: Non significant; PS-13: Pirsabak-13.

It could be inferred that the wheat genotypes PR-115, PR-118 and PR-120 have genetic potential and produced higher grain yield and related traits then other contesting genotypes under full and deficit water and can be utilized in future wheat breeding programme. Irrigation of wheat genotypes at critical growth stages enhanced plant height, yield and related components except days to maturity. In full water availability, the current research recommends the farmers to irrigate wheat at seedling, tillering, booting and grain formation stages for higher yield. In case of water scarcity, irrigation at seedling and booting is strongly recommended to trim down tremendous yield losses.

References

Allahverdiyev TI, Talai JM, Huseynova IM and Aliyev JA 2015. Effect of drought stress on some physiological parameters, yield, yield components of durum (*Triticum durum* Desf.) and bread (*Triticum aestivum* L.) wheat genotypes. Ekin. J. Crop Breed. and Genet **1**(1): 50-62.

Albokari MMA, Khashoggi AJ and Almuwalid MA 2016. Effect of different irrigated conditions on some morphological traits of wheat genotypes grown in Saudi Arabia. Pak. J. Bot. **48**(2): 519-526.

AL-Harbi AR, Al-Omran AM, Alenazi MM and Wahb-Allah MA 2015. Salinity and deficit irrigation influence tomato growth, yield and water use efficiency at different developmental stages. Int. J. Agric. Biol. **17**(2): 241-250.

Ali MH, Hoque MR, Hassan AA, and Khair A 2007. Effects of deficit irrigation on yield, water productivity, and economic returns of wheat. Agric. water Manag. **92**: 151-161.

Baloch SU, jun LL, Kandhroo MN, Fahad S, Sabiel SA, Baloch SK and Badini SA 2014. Effect of different irrigation schedules on the growth and yield performance of wheat (*Triticum aestivum* L.) varieties assessment in District Awaran (Balochistan). J. Biol. Agric. Healthcare **4**(20): 5-17.

Bux H, Rasheed A, Sial MA, Kazi AG, Napir AZ and Kazi AM 2013. An overview of stripe rust of wheat (*Puccinia striiformis* f. sp. *tritici*) in Pakistan. Arch. Phytopathology. Plant Prot. (UK) **45**(19): 2278-2289.

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

Du T, Kang S, Sun J, Zhang X and Zhang J 2010. An improved water use efficiency of cereals under temporal and spatial deficit irrigation in north China. Agric. Water Manag. **97**: 66-74.

GOP 2014. Economic Survey of Pakistan. pp 34.

Ibrahim ME, Abdel-Aal SM, Seleiman MFM, Khazaei H and Monneveux P 2011. Effect of different water regimes on agronomical traits and irrigation efficiency in bread wheat (*Triticum aestivum* L.) grown in the Nile Delta. J. Agric. Res. Tanta Univ. **31**:28-33.

Karousakis K and Koundouri P 2006. Water management in arid and semi-arid regions: Interdisciplinary perspective - An introduction. P. Koundouri, K. Karousakis, D. Assimacopoulos, P. Jeffrey and M.A. Lange (Eds.). Edward Elgar Publishing, Inc. USA. pp. 3-13.

Khokhar B, Hussain I and Khokhar Z 2010. Effect of different irrigation frequencies on growth and yield of different wheat genotypes in Sindh. Pakistan J. Agric. Res. **23**: 3-4.

Li YF, Wu Y, Espinosa NH and Peña RJ 2013. Heat and drought stress on durum wheat: Responses of genotypes, yield, and quality parameters. J. Cereal Sci. **57**(3): 398.404.

Liu J, Williams JR, Zehnder AJB and Yang H 2007. GEPIC - modelling wheat yield and crop water productivity with high resolution on a global scale. Agric. Systems **94**: 478-493.

Maqsood M, Azam ASN 2007. Effects of drought on growth, development, radiation use efficiency and yield of finger millet (*Eleucine coracona*). Pak. J. Bot. **39**(1): 123-134.

Ngwako S, and Mashiqa PK 2013. The effect of irrigation on the growth and yield of winter wheat (*Triticum aestivum* L.) cultivars. Int. J. Agri. Crop Sci. **5** (9): 976-982.

Onyibe JE 2005. Effect of irrigation regime on growth and development of two wheat cultivars (*Triticum aestivum* L.) in the Nigerian Savanna. J. Agri. Rural Dev. Trop. **106**(2): 177-192.

Rebetzke GJ and Richards RA 1999. Genetic improvement of early vigor in wheat. Aust. J. Agric. Res. **50**: 291-301.

Reynolds MP, Skovmand B, Trethowan RM and Pfeiffer WH 1999. Evaluating a concept model for drought tolerance. *In:* Using Molecular Markers to Improve Drought Tolerance. (Ed.): J.M. Ribaut, Mexico,

Rogers P, and Lydon P 1994.Water in the Arab World: Perspectives and Prognoses, The Division of Applied Sciences. Harvard University, Cambridge. 267-316.

Sarkar SA, Ullah DMJ, Shahriar SA, Shathi MSA and kaes I 2017. Response of yield performance of wheat to irrigation regime and sowing time. Int. J. Agron. Agri. Res. **10** (6):76-84.

Sarwar N, Maqsood M, Mubeen K, Shehzad M, Bhullar MS, Qamar R and Akbar N 2010. Effect of different levels of irrigation on yield and yield components of wheat cultivars. Pak. J. Agri. Sci. **47**(3): 371-374.

Shahryari R, Valizadeh M and Mollasadeghi V 2011. Evaluation of irrigation levels and its impact on quality and quantity performance of wheat. Adv. Environ. Biol. **5**(3): 528-534.

Shehzadi S, Shah Z and Mohammad W 2017. Impact of organic amendments on soil carbon sequestration, water use efficiency and yield of irrigated wheat. Biotechnol. Agron. Soc. Environ. **21**(1): 36-49.

Steel RGD, Torrie JH and Dickey DA 1997. Principles and procedures of statistics: A biometrical approach, 3rd Ed. McGraw Hill Book Company, New York pp. 172-177.

Strauss JA and Agenbag GA 2000. The use of physiological parameters to identify drought tolerance in spring wheat cultivars. S. Afr. J. Plant and Soil **17**(1): 20-29.

(Manuscript received on 19 September, 2018; revised on 26 December, 2018)