Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2013, 4 (5):222-227
(http://scholarsresearchlibrary.com/archive.html)

Scholars Research Library
ISSN 0976-1233
CODEN (USA): ABRNBW

Effect of different irrigation regimes on yield and water use efficiency of winter wheat

Keyvan Shamsi* and Soheil Kobraee

Department of crop production and Plant Breeding, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran

ABSTRACT

For the purpose of studying the effects of water deficit stress on yield and water use efficiency of three wheat cultivars under field condition, an experiment was initiated in Research Farm of Islamic Azad University located in Kermanshah/Iran during 2010-2011. The experimental treatments were arranged as split plots based on a randomized complete block design with three replications. The main plots were allocated to four different irrigation regimes : I_1- full irrigation (irrigation during growth period after 40% depletion of soil moisture) I_2 - drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture; I_3 - drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture; and I_4 - drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moistur. The subplots were allocated to three Cultivars treatments of C_1 (Roshan- Back Cross), C_2 (Karaj 1) and C_3 (Marvdasht). The results showed that with increasing drought stress grain yield, biological yield, harvest index and water use efficiency decreased but evapotranspiration efficiency (ETE) was increased. Under control (I1) conditions, WUE mean was 1.27 kg.m-3 for all cultivars, but equal to 1.11, 0.91 and 0.73 kg.m-3 for stress treatments I_2, I_3, and I_4, respectively. The highest and lowest harvest index and water use efficiency were observed for Roshan-Back Cross cultivar and Mrvdasht cultivar under well- watering, respectively. The Roshan-Back Cross cultivar had higher yield stability than the others and its yield reduction under stress conditions was lower than others.

Keywords: Wheat, water deficit stress, Water use efficiency, Harvest index, Yield

INTRODUCTION

Drought stress is one of the most important and effective factors in agricultural practices in arid and semi-arid regions of the worlds. Wheat is planted on about 100 million hectares in the developing world, excluding the countries of Central Asia and the Caucasus. Wheat (*Triticum aestivum* L.) is a staple food for more than 35% of the world's population and it is also one of the most important cereal crops in Iran. It is the most widely grown cereal grain with 65% (6.5 million hectares in 2010) of the total crop cultivated area in Iran Crop production in arid and semi-arid regions is most limited by water scarcity. In most parts of Iran, limited precipitation is mainly occurred in cold and winter seasons and cannot be directly used by plants[9].Therefore, shortage of water resources has become the major limiting factor for wheat production[14]. Water deficit affects every aspect of plant growth by modifying the anatomy, morphology, physiology, biochemistry and finally the productivity of a crop [1]. Moisture stress during spike emergence and anthesis has been reported to reduce grain yield up to20% mainly through reduction of individual grain weight[10].Other study have shown that the water stress at anthesis stage reduces pollination and number of grains per spike which results in the reduction of grain yield[22].Water stress experienced by a wheat crop during growth stages is known to have cumulative effects expressed as a reduction in total biomass as compared to well-watered conditions[13].Setter *et al*(2001) observed that stress during grain filling reduced yield by 20% mainly due to 16% reduction in individual grain weight[19].The meaning of WUE, as a comparative measure of plant productivity per unit of water used, depends on the unit with which productivity (photosynthesis or biomass accumulation) and WU (transpiration, evapotranspiration or precipitation/ irrigation) are expressed, at leaf, plant or canopy level[17].

Therefore, the goal of the present study was to evaluate the effect of different irrigation regimes on the grain yield and water use efficiency (WUE) of three wheat cultivars.

MATERIALS AND METHODS

To study the effects of drought stress on water use efficiency of three wheat cultivars under field condition, an experiment on research farm; Islamic Azad University, Kermanshah/Iran ,was performed in 2010-2011. The experimental treatments were arranged as split plots based on a randomized complete block design with three replications. The main plots were allocated to four different irrigation regimes:I_1-full irrigation (irrigation during growth period after 40% depletion of soil moisture) I_2-drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture; I_3- drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture; and I_4 - drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moisture. The subplots were allocated to three Cultivars treatments of C_1 (Roshan-Back Cross), C_2 (Karaj1) and C_3 (Marvdasht). Soil texture was silty clay. Annual average precipitation was 420 mm.The soil preparation consisted of mouldboard ploughing (15-25 cm) followed by discing and smoothing with a land leveler. Each plot consisted of six rows of 4 m long and 20 cm apart. One and two meters distance was taken between test plots and blocks, respectively. Wheat seeds were sown on 10 November 2010. The density was 400 seeds per square meter. Irrigation intervals were regulated according to the irrigation treatments. At maturity, 20 plants from the four middle rows next to guard rows were harvested and grain yield (kg ha-1), biological yield (kg ha-1) and harvest index (%) was measured. For grain yield, sun dried wheat was threshed and grain yield was recorded from each plot. Harvest index indicates the ratio of economical yield to the biological yield. It was calculated by the following formula.

H.I (%) = (Economical yield / Biological yield) × 100

Water use efficiency and evapotranspiration efficiency (ETE) were calculated using equation 1 and equation 2 based on Ehdaie & Waines, (1994), method respectively [6].

$$WUE\ (kg.m^{-3}) = \frac{Grain\ yield}{water\ used\ rate} \quad (1)$$

$$ETE\ (kg.m^{-3}) = \frac{Biological\ \ yield}{water\ used\ rate} \quad (2)$$

Analysis of variance of the data was carried out by using MSTATC and SPSS soft-wares. Means were compared by Duncan's multiple range test at P≤0.05.Excel software was used to draw figures.

RESULTS AND DISCUSSION

The grain yield, biological yield, harvest index and water use efficiency were significantly affected by irrigation regimes and cultivars (P≤0.01). Grain yield, biological yield, harvest index and water use efficiency decreased with decreasing water availability (Table1, 2).

The grain yield, biological yield, harvest index and water use efficiency of Roshan-Back Cross cultivar was significantly more than that of the other wheat cultivars. The highest of this factors was achieved in control (I1), but the lowest of grain yield, biological yield related to I_3 and the lowest of harvest index and water use efficiency related to I_4. The highest of This factors was from Roshan-Back Cross cultivar and the lowest of them was from Marvdasht cultivar (Table 2). In recent years many approaches to select wheat genotypes which are resistant to drought were described, e.g. improved water use efficiency[3,4,11].Sarmadnya and Kocheki,(1992) reported that Studies under water deficit and no water deficit conditions showed that wheat cultivars vary in their sensitivity to drought depending on the intensity of the stress[18],also Chandler and Singh (2008) reported that grain yield and biological yield particularly showed maximum sensitivity to moisture stress[5]. It is also envisaged from present research that not only the drought but timing of drought is also important for some traits in wheat and other cereal crops [16], such as yield was significantly decreased when stress was given at after anthesis stage.this reports are in agreement with findings of this research. Experimental results showed that under drought stress conditions, wheat cultivars WUEs were significantly lower than under non- stress conditions (control). Under control (I_1) conditions, WUE mean was 1.27 kg.m-3 for all cultivars, but equal to 1.11, 0.91, and 0.73 kg.m-3 for stress treatments I_2, I_3, and I_4, respectively. The interaction of irrigation×cultivar for harvest index and water use efficiency was also significant($P \leq 0.01$).The highest and lowest harvest index and water use efficiency were observed for Roshan-Back Cross cultivar and Mrvdasht cultivar under well- watering,respictevely(Figure2,3). It can be concluded that grain yield increased more intensely as water utilization increased in the unit area resulting in an increase in water use efficiency. Under moist stress condition at stages (I_2),(I_3)and(I_4) a decrease in water use efficiency in the unit area reduced yield compared to the control condition (I_1) which resulted in a decrease in water use efficiency. Roshan-Back Cross cultivar with lowest water used under different irrigation regimes had highest grain yield to other cultivars (Figure1, table2). The Variation trend of WUE was almost similar to that of grain yield and there was a correlation between them. So it can be concluded that grain yield increased more intensely as water utilization increased in the unit area resulting in an increase in WUE. Grain yield showed that positive and significant correlation with HI, WUE, ETE and TWE and the significant negative correlations were indicated between ETE and BY, HI and WUE under different irrigation regimes (Table3). Ezzat Ahmadi et al. (2009), Attarbashi et al. (2002) and Singh et al. (2002) reported that grain yield was positively associated with biological yield and harvest index [2, 7, and 21]. Also Some of researchers indicated that the positive correlation between grain yield and yield component traits in wheat such as harvest index[8] , biological yield[8,12].On the other hand, These results are in agreement with reports of Nouri ganbalani (2009) and Shamsi et al. (2010)[15,20]. Generally, the results of the present study showed that Roshan-Back Cross cultivar had higher yield stability than the others and its yield reduction under stress conditions was lower than others.

Table 1. Analysis of Variance on grain yield and traits evaluated on different irrigation regimes.

		MS (means squares)				
Source of Variation	**d.f**	**GY (kg.h^{-1})**	**BY (kg.h^{-1})**	**HI (%)**	**WUE (kg.m^{-3})**	**ETE (kg.m^{-3})**
Replication	**2**	**977377.544**	**1587684.882**	**45.518**	**0.052**	**0.188**
Water stress	**3**	**3639250.861****	**26835635.992****	**949.891****	**1.067****	**6.328^{ns}**
Error	**6**	**173723.289**	**2054427.563**	**3.618**	**0.025**	**0.006**
Cultivar	**2**	**2074305.907****	**728492.838***	**66.399****	**0.146****	**0.361^{ns}**
Water stress × cultivar	**6**	**186696.877^{ns}**	**2333578.209^{ns}**	**9.258****	**0.016****	**0.72^{ns}**
Error	**12**	**134582.785**	**2279329.407**	**2.069**	**0.021**	**0.026**
Coefficient Variation (%)	**-**	**9.54**	**11.45**	**6.84**	**9.48**	**13.83**

$P^{*} < 0.05$, $P < ^{**}0.01$; ns: Non- signification. GY: grain yield; BY: biological yield; HI: harvest index; WUE: water use efficiency: ETE: evapotranspiration efficiency.

Table 2. Effect of cultivar and different irrigation regimes on grain yield and traits evaluated.

Traits	GY (kg.h^{-1})	BY (kg.h^{-1})	HI (%)	WUE (kg.m^{-3})	ETE (kg.m^{-3})
I_1	6632 a	13690 a	48.74 a	1.275 a	2.469a
I_2	4607 b	12440 b	38.79 b	1.110 b	2.291 a
I_3	3576 d	10600 c	33.95c	0.9108 c	2.357a
I_4	4210 c	11780 b	35.01 c	0.7323 d	3.625 a
C_1	4984 a	12547 a	39.77 a	1.065 a	2.707 a
C_2	4857 a	12211 b	39.58 a	1.013 b	2.652 a
C_3	4236 b	11115 c	37.98 b	0.9351 c	2.565 a

Mean followed by similar letters in each column are not signitifinty different at 5% probability level using Duncan`s Multiple Range Test. GY: grain yield; BY: biological yield; HI: harvest index; WUE: water use efficiency: ETE: evapotranspiration efficiency; I_1,I_2,I_3 and I_4: full irrigation (irrigation during growth period after 40% depletion of soil moisture);drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture; drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture; and drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moisture. C_1, C_2 and C_3: Roshan-Back Cross, Karaj1 and Marvdasht cultivars.

Table 3. Coefficients of correlation between different traits.

Traits	GY	BY	HI	WUE	ETE	TWE
GY	1					
BY	0.702**	1				
HI	0.941**	0.558**	1			
WUE	0.874**	0.567**	0.906**	1		
ETE	0.401**	-0.303**	-0.409**	-0.662**	1	
TWE	0.538**	0.228**	0.545**	0.534**	0.586**	1

*Ns, *and **: not significant, significant at 5% and 1% levels, respectively.GY: grain yield; BY: biological yield; HI: harvest index; WUE: water use efficiency; ETE: evapotranspiration efficiency; TWE: total water used*

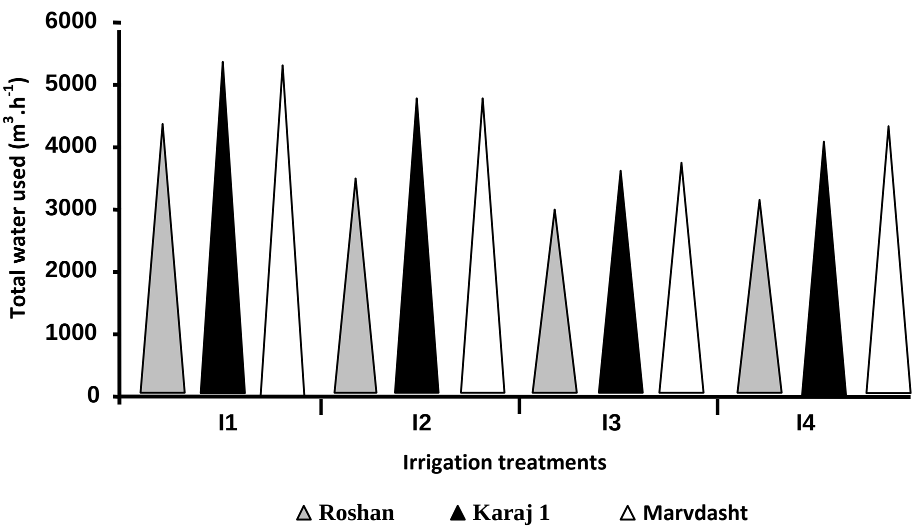

Figure1.Total water used on every treatment for different cultivars.

I_1- full irrigation (irrigation during growth period after 40% depletion of soil moisture) I_2-drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture; I_3 - drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture; and I_4 - drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moisture. C_1, C_2 and C_3: Roshan- Back Cross, Karaj1 and Marvdasht cultivars.

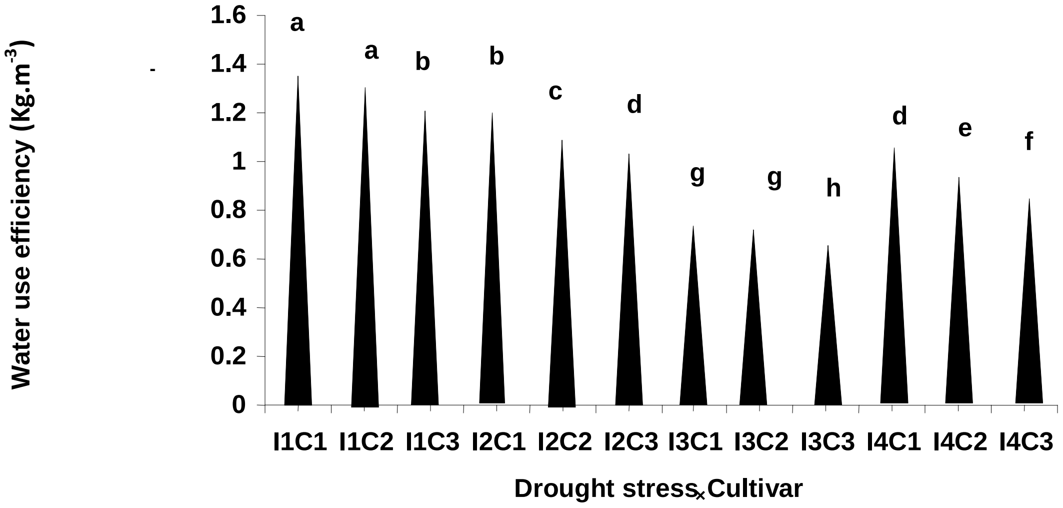

Figure2. Interaction effects of different irrigation regimes and cultivar on water use efficiency.

Bars with similar letters at the top, are not significantly different at 5% probability level using Duncan`s Multiple Range Test. I_1,I_2,I_3 and I_4:full irrigation (irrigation during growth period after 40% depletion of soil moisture);drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture; drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture;and drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moisture. C_1, C_2 and C_3: Roshan- Back Cross, Karaj1 and Marvdasht cultivars.

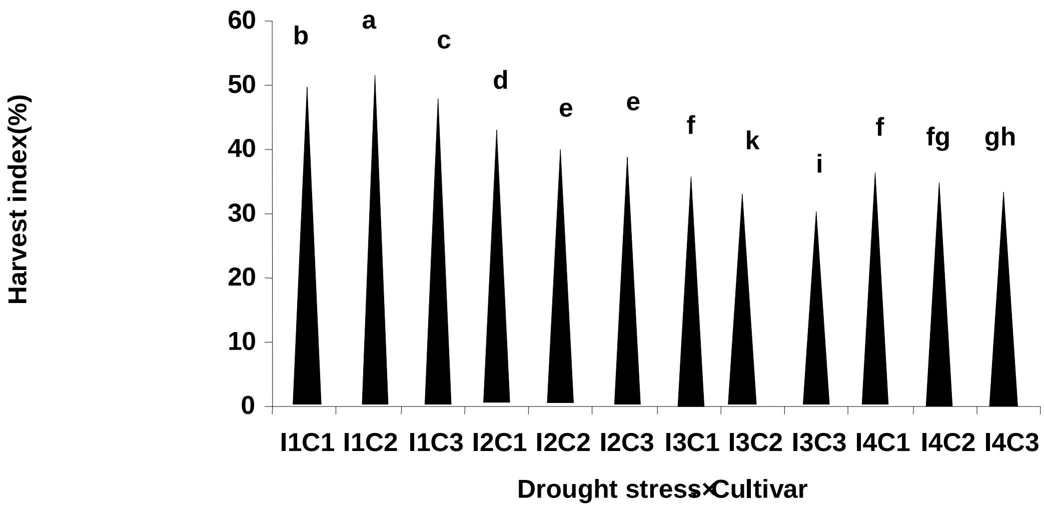

Figure3. Interaction effects of different irrigation regimes and cultivar on harvest index.

Bars with similar letters at the top, are not significantly different at 5% probability level using Duncan`s Multiple Range Test. I_1,I_2,I_3 and I_4:full irrigation (irrigation during growth period after 40% depletion of soil moisture);drought stress at the start of anthesis stage (56 Zadoks) through the grain filling stage(70 Zadoks) with irrigation after 80% depletion of soil moisture;drought stress at the start of anthesis stage(56 Zadoks) through the ripening stage with irrigation after 80% depletion of soil moisture; and drought stress at the start of grain filling stage (70 Zadoks) through the ripening with irrigation after 80% depletion of soil moisture. C_1, C_2 and C_3: Roshan-Back Cross, Karaj1 and Marvdasht cultivars.

Acknowledgment
The authors are thankful to the Department of Crop production and plant breeding, Islamic Azad University Kermanshah Branch for providing financial support to conduct this research.

REFERENCES

[1] M Ashraf. Harris PJC. *Field Crop Absts.* **2005**, 6,725-730.
[2] MR Attarbashi.Galeshi S. Soltani A. Zinali E. *Iranian J Agric Sci.* **2002**, 33, 21–28.
[3] A Blum. *Aust. J. Agr. Res* .**2005**, 56, 1159-1168.
[4] L Chaerle. Saibo N.Van Der Straeten D.*Trends Biotechnol*. **2005**, 23, 308-315.
[5] SS Chandler.Singh TK.*Proceedings of the 11th International Wheat Genetics Symposium*. Sydney University Press, Australia. **2008**, pp1-3.
[6] B Ehdaie. Waines, JG. *Crop Sci*.**1994**, 34, 1443-1451.
[7] M Ezzat Ahmadi.Noormohammadi Gh.Ghodsi M. Kafi M. *J. Biolog. Sci*.**2009**, 12, 1399-1407.
[8] MG Ghaderi. Zeinalikhanghah H. Hosseinzadeh AH. Taleei AR. Naghavi MR.*J crop Res* .**2009**, 7(2), 573-582, (In Persian).
[9] H Ghamarnia. Gowing JW. *Proceeding of the ICID 21th European Regional Conference*.May 15-19, Frankfurt (Oder) and Slubic-Germany and Poland.**2005**, pp 1-4.
[10] A Hagyo. Farkas C. Lukacs A. Csorba S. Nemeth T. *Cereal Res. Comm*. **2007**, 35,437- 440.
[11] Yc HU. Shao HB. Cuuly Gang W. *Colloid Surface B* .**2006**, 53, 271-277.
[12] V Kandic. Dodig D. Jovic M. Nikolic B. Prodanovic S.*Genetika* .**2009**, 41(1), 11-20.
[13] AA Mirbahar. Markhand GS.Mahar AR . *Pak. J. Bot*. **2009**, 41, 1303-1310.
[14] A Nasseri. Fallahi HA. *J. Bio. Sci*.**2007**, 7, 19-26.
[15] A Nouri-Ganbalani. Nouri-Ganbalani G. Hassanpanah D. *J. Food Agric*. *Environ*. .**2009**, 7(3&4), 228-234.
[16] RA Richards. *Australian Journal of Agricultural Research*. **1992**, 43, 517-527.
[17] FB Salisbury.Stress Physiology. In: Salisbury, F.B. (Ed.), Units, Symbols, and Terminology for Plant Physiology. Oxford University Press. **1996**. pp142–159.
[18] Gh Sarmadnya. Koocheki A.Physiological aspects of rain-fed agriculture. Mashhad University Press Jihad. **1992**, pp 424, (In Persian).
[19] TL Setter. Brain AF. Melkonian J. *Crop Sci*. **2001**, 41, 1530-1540.
[20] K Shamsi. Petrosyan M. Noor Mohammadi G. Haghparast R. *J. Appl. Biosci*.**2010**, 35, 2325-2331.
[21] M Singh. Lalta P. Swarnkar G. Pl Archives Muzafarabad. **2002**, 2,215–218.
[22] X Zhang. Chen S. Sun H. Pei D. Wang Y. *Irrig. Sci*. **2001**, 27, 1-10.