Water- use Efficiency of Two Wheat Cultivars (*Triticum aestivum* L.) under Tropical High Terrace Soil Conditions

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ABSTRACT— ***The water – use efficiency, growth and yield of two wheat cultivars (Triticum aestivum L.) under tropical high terrace soil conditions were investigated. This study was conducted for two consecutive winter seasons (2009/10-2010/11) at the Experimental Farm of the Faculty of Agriculture, Nile Valley University, Darmali, Sudan. The experiment design was randomized complete block in split plot arrangement with three replications. The treatments consisted of five irrigation levels (0.4 ET "I_1", 0.6 ET "I_2", 0.8 ET "I_3", 1 ET "I_4" and 1.2 ET "I_5") occupied the main plots and the two wheat cultivars (Emam and condor) were the sub-plots. The results showed that the leaf area index, plant height, spike length, harvest index, 1000- kernel weight and grain yield were significantly increased by increasing irrigation levels. The highest grain yield among two cultivars across irrigation levels was produced by Emam (2335 kg ha^{-1}). However, the lowest grain yield was produced by Condor cultivar (1348 kg ha^{-1}). Irrigation level treatments I_5 and I_4 gave significantly the highest grain yield 2112 kg ha^{-1}and 2024 kg ha^{-1}, respectively. Whereas the lowest grain yields (1424 kg ha^{-1}) was observed at irrigation treatment I_1. The results indicated a highly negative relationship between grain yield and water-use efficiency. Water-use efficiency decreased with increasing irrigation level treatments. Emam cultivar, with higher grain yield, tended to have higher water-use efficiency than Condor cultivar. So it was concluded that, to grow Emam cultivar with the irrigation level 1 ET "I4" is the best management for optimizing wheat yield under tropical high terrace soil conditions.***

Keywords— Irrigation Level; Water Stress; Water-use Efficiency; Grain Yield; Leaf Area Index; Harvest Index; Wheat

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1. INTRODUCTION

Wheat (*Triticum aestivum* L.) production is of a great effect on global food security and this is due to the increasing demand and high prices in the world market. It is one of the most important cereal crops in Sudan. Its cultivated along the Nile banks in the Northern region, between latitudes 16^o and 22^o N. Wheat in Sudan is grown under irrigation during the short dry and comparatively cool winter season that extends from November to March. The hot dry short season and inadequate irrigation water are the major factors responsible for the commonly low yields.

The Sudan wheat situation is characterized by rapid growth in consumption, continuous and variable deficit between domestic need and local production. Wheat consumption has been increases by 138% from 1980 to 2010.Wheat imports have increased considerably and on average three quarters of the wheat consumed during 2000-2010 was imported [1].

Wheat yields are very sensitive to planting dates, irrespective of the varieties used. In the long term, yield increases will largely depend on improvements of heat-tolerant and short duration wheat varieties [2].

Given, limitations in water supply, in arid and semi-arid areas, and the horizontal and vertical expansions in irrigated areas require changes in irrigation programs by developing efficient irrigation methods and/or culturing genotypes with high water use efficiency. In Sudan agricultural irrigated area is approximately 2.8 million hectares and about 213 thousand hectares are being cultivated annually with wheat [3].

Water use efficiency represents a given level of biomass or grain yield per unit of water used by the crop and is obtained through marketable yield or biomass over plant evapotranspiration [4, 5]. Therefore, water demand for irrigation can be reduced and the water saved can be diverted for alternative uses. In areas where water is the most limiting factor, maximizing water production may be economically more profitable for the farmer than maximizing yields [6].

To cope with scarce supplies [7] stated that deficit irrigation is defined as the application of water below full crop-water requirements. Deficit irrigation has been widely investigated as a valuable and sustainable production strategy in dry regions. By limiting water applications to drought-sensitive growth stages, this practice aims to stabilize yields for obtaining maximum water production rather than maximum yields [8, 9].

Too much irrigation decreases crop water- use efficiency and effective deficient irrigation may result in a higher water use efficiency [10]. It was possible to increase crop water use efficiency by 25-40% through managing soil moisture content [5].

In recent years, some researchers found that good management and adoption of appropriate practices could improve agricultural water use and crops production would be more efficient [11]. At present, most researches are focused on how to maintain the best economic productivity and highest water use efficiency in arid and semi-arid areas [12].

Deficit irrigation in high terrace soil has not received sufficient attention in applied research although, globally practiced over millions of hectares. Therefore, the main objectives of this study is to investigate the effects of different water regimes on growth, yield, yield components and water- use efficiency of two wheat cultivars under high terrace soils of River Nile State, Sudan.

2. MATERIALS AND METHODS

Field experiments were conducted during 2009/2010 and 2010/2011 seasons at the Experimental Farm of the Faculty of Agriculture, Nile Valley University, Darmali, Sudan (17°48' N; 34°00' E; altitude 346.5 meters). Soil physical and chemical properties for the experimental site was analyzed in Hudeiba Research Station Laboratory and were presented in Table 1.

The climate data was obtained from Atbara meteorological station. Monthly means for 30 years (1971 – 2000) were presented in Table 2. The calculation of reference evapotranspiration (ETo) is based on the FAO Penman-Monteith method [13]. Irrigations were added with 7 days intervals. Before starting the experiment, plants were irrigated to the field capacity for two weeks in order to improve root development.

The experiment was laid out in randomized complete block in split plot design arrangement with three replications. Treatments considering five irrigations levels (0.4 ET "I1", 0.6 ET "I2", 0.8 ET "I3", 1 ET "I4" and 1.2 ET "I5") were randomly assigned to main plots and two cultivars (Emam and condor) as subplots. The irrigation application to each field was measured using a water meter which was installed at the hydrant of a low-pressure tube water transportation system.

The land was prepared by disc plough and disc harrow then each plot was levelled manually. Each plot has dimensions of 8 ×1.6 m. Plots in each replication were separated by buffer zone of 3 m wide to eliminate runoff. The two wheat cultivars were sown on the 21th November 2009 and 25th November 2010 in the first and second season, respectively at a seed rate of 120 kg ha^{-1}. Planting was done manually by hand dibbling.

Urea (46% N) was applied in split dose as a source of nitrogen, half-dose applied at sowing and the rest four weeks after sowing. Triple super phosphate (48% P2O5) was applied as a source of phosphorous before sowing. The two cultivars were kept clean by hand weeding two and three weeks after sowing, respectively.

Plants were harvested as they dried up. Shoots were removed manually by cutting at the soil surface. Plants were harvested, bound and air dried before threshing and measuring seed yield per unit area.

Leaf area index was fortnightly calculated by the following formula suggested by [14]:

$$\text{Leaf area per plant (cm}^2\text{)} = \text{length} \times \text{maximum width} \times 0.79 \quad \dots (1)$$

$$\text{Leaf area index} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{ground area per plant (cm}^2\text{)}} \quad \dots. (2)$$

Table 1: Physical and chemical properties of soil at the study site.

Soil properties	Result
Calcium Carbonate	15%
Organic matter	0.042%
Nitrogen	140PPM
Phosphorus	1.1 PPM
EST	1.2%
Electric conductivity	0.85 d/m
Soil texture	Sand 35%, Clay 63% and Silt 2%
P^H	7.4

Table 2: Climatologically normal's 1971 – 2000, Atbara Station.

Mon.	Air temperature in °C				Bright sunshine duration		Relative humidity %	Wind mean speed at 2 m km hr^{-1}	*ETo mm
	Maximum		Minimum						
	MEAN	HST	MEAN	LST	HRS	%	MEAN		
Jan	29.8	39.1	14.2	6.3	9.9	88	36	8.0	6.3
Feb	31.8	41.4	15.1	5.5	10.3	90	31	8.0	7.2
Mar	35.7	45.7	18.4	10.8	10.1	84	24	8.0	8.1
Apr	40.0	46.3	22.1	15.0	10.6	85	23	6.9	8.1
May	42.6	47.5	26.5	18.9	9.8	75	23	5.7	7.5
Jun	43.2	48.0	28.0	21.6	8.6	65	22	5.7	7.4
Jul	41.2	47.7	27.3	19.5	8.7	65	32	6.9	8.1
Aug	40.6	46.5	26.9	19.5	8.6	67	37	6.9	7.8
Sep	41.6	47.6	27.4	20.0	8.6	71	32	6.9	7.7
Oct	39.7	44.5	25.2	16.0	9.8	83	31	5.7	6.6
NOV	34.9	40.7	20.1	11.7	10.2	90	36	6.9	6.3
DEC	31.1	38.5	16.0	6.5	9.7	88	40	6.9	5.7
Year	**37.7**	**48.0**	**22.3**	**5.5**	**9.6**	**79**	**31**	-	-

Source: Sudan Meteorological Authority, Atbara Station.
* Calculated by using Penman – Montieth equation.

Data were observed on ten plants randomly selected from the harvested area. Parameters assessed included, plant height (from the ground surface to tip of growing point) and 1000-kernel weight (g). Harvest index was calculated as the average grain yield per plot divided by the average dry biomass per plot. Seed yield per unit area was obtained from the three center rows of each plot. To avoid border effect 0.5 m of every side in each plot was not considered when harvesting, then grain yield was determined in kg ha^{-1}. Water use efficiency (WUE) was estimated as the ratio of grain yield (kg) to total water used (m^3). Water-use efficiency was calculated as described by [15] as follows:

$$WUE = \frac{GY}{ET} \quad ..... (3)$$

Where,

WUE (kg m^{-3}) is the water-use efficiency for the GY (kg m^{-2}) and ET is evapotranspiration (m).

The data were statistically analyzed using analysis of variance to test the significance of treatment effects by using the SPSS statistical program. Least Significant Difference Test was used to compare treatment means as described by [16].

3. RESULTS AND DISCUSSION

3.1 Leaf area index

Leaf area index as affected by irrigation levels and cultivars Figure 1(a) and (b). In all irrigation levels leaf area index increased steadily till 70 days after sowing and declined thereafter due to leaf senescence. The maximum leaf area index was attained at higher irrigation levels. However a reduction in the leaf area index was recorded at irrigation level treatments I_1 and I_2.This might be due to that available soil water is less than root water extraction efficiency. During wheat vegetative growth, under water stress, leaves became smaller, which results in low leaf area index [17]. Emam cultivar produced the higher Leaf area index than Condor Figure 2(b). Several studies indicated that total resistance in the soil plant system increases with decreasing soil-water potential, which leads to a reduced photosynthetic activity and growth [18, 19].

3.2 Plant height

Plant height was significantly affected by cultivars. Emam cultivar gave significantly higher plants than condor (Table 3). However, plant height was significantly affected by irrigation levels. The results indicated a decline in plant height in the two cultivars under stress conductions, which may be due to decrease in relative turgidity and dehydration of protoplasm which associated with loss of turgor and reduced expansion of cell and cell division [20].

3.3 Spike length

The spike length was affected significantly by irrigation levels and cultivars (Table 3). Irrigation level treatment I_5 gave the highest spike length. Emam cultivar gains significantly higher spike length than condor. Similar result of minor decreases in spike length following irrigation levels deficit was obtained by [21].

3.4 1000- kernel weight

One thousand kernel weight was significantly increased with high irrigation levels than low irrigation level (Table 3). These results are in agreement with [22]. The maximum 1000-kernel weight (35 g) was found under I_5 irrigation treatment and the lowest (31 g) was found at I_1 irrigation treatment. The decrease in 1000-kernel weight may be due to disturbed nutrient uptake efficiency and photosynthetic translocation within the plant, which produced shrivelled grains due to hastened maturity [23].

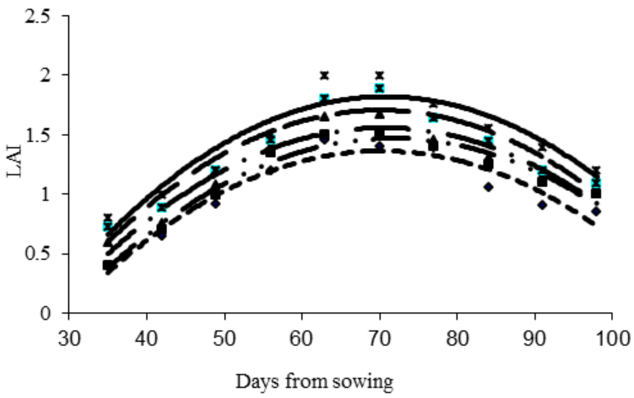

Figure 1 (a): Leaf Area Index as Affected by Different Irrigation Levels (I_1 ♦--- , I_2 ■— ·· , I_3 Δ— · - , I_4 —✱— and I_5 —✱-) During 2010/2011 Growing Season

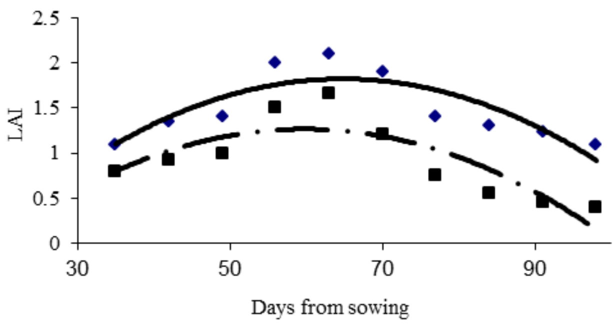

Figure 1 (b): Leaf Area Index as Affected by Two Cultivars (Emam♦— and Condor ■—·) During 2010/2011 Season

3.5 Harvest index

Harvest index was significantly affected by irrigation levels and cultivars (Table 3). The highest harvest index (27.6%) was recorded at irrigation treatment I_5, which could be due maximum translocation of assimilates to grain formation. On the other hand irrigation treatments I_1 and I_2 attained the lowest harvest index 23.1 and 25.1%, respectively. The studies revealed that water stress at different growth stages of wheat significantly reduced total dry weight, grain yield and harvest index. Moreover, the effect of water stress varies with the intensity of stress and the growth stage at which it occurs [24]**.**

3.6 Grain yield

Irrigation levels and wheat cultivars had significant effect on the grain yield. The highest grain yield among two cultivars across irrigation levels was produced by Emam (2335 kg ha^{-1}) (Table 3). However, the lowest grain yield was produced by Condor (1348 kg ha^{-1}). The combined analysis over two growing seasons for the irrigation levels recorded significant effect. Irrigation level treatments I_5 and I_4 gave significantly the highest grain yield 2112 kg ha^{-1} and 2024 kg ha^{-1}, respectively. Whereas the lowest grain yields (1424 kg ha^{-1}) was observed at irrigation treatment I_1. This might be due to leaf area index, spike length, 1000-kernel weight and Harvest index. Grain yield was affected by both the magnitude of water deficit and storage of growth subjected to deficit. Increasing irrigation amount up to 100% of soil moisture significantly increased grain yield [25]. The interaction between wheat cultivars and irrigation levels showed no significant effect in both seasons indicating that, wheat cultivars behave similar under different irrigation levels [26]. The grain yield was lower for I_1 treatment, this could be due to that soil moisture depleted sufficient enough to limit extraction of water by root and thereby water stress caused large deficiencies in grain yield. The results were similar to the findings of [27] and [28] who noted rational irrigation significantly increased biomass and grain yield.

Table 3: Effect of irrigation levels on grain yield and yield components of wheat cultivars over two seasons, (2009/2010 and 2010/2011).

Treatments	Grain Yield (Kg ha^{-1})	Spike Length (cm)	Plant Height (cm)	1000-Kernel Weight (g)	Harvest Index (%)
Cultivars:					
Emam	2235	5.4	59.14	32.98	26.3
Condor	1348	4.4	50.88	32.88	25.1
LSD (P= 0.05)	696.8	4.9	6.49	0.078	0.927
Irrigation levels:					
I_1	1424	4.3	53.9	30.8	23.1
I_2	1555	4.3	54.4	31.7	25.1
I_3	1845	4.5	54.9	33.4	25.8
I_4	2024	4.7	55.2	34.0	26.6
I_5	2112	4.8	56.7	35.1	27.6
LSD (P= 0.05)	512.5	0.39	1.838	3.01	2,92
Interaction	NS	NS	NS	NS	NS

Least Significant Difference Test is significant at the 0.05 level, (NS) not significant.

3.7 Relationship between grain yield and water-use efficiency

Figure 2 illustrates the relationship between grain yield and water-use efficiency over two growing seasons**.** The results indicated a highly negative and significant relationship (R=0.94) between grain yield and water-use efficiency. The maximum water-use efficiency is equivalent to transpiration efficiency, where there was no water loss from the soil surface [8]. Water-use efficiency decreases with increasing irrigation level treatments. These results are in agreement with those obtained by [29] and [27]. Reports by [30] indicated that irrigation water-use efficiency for biomass and grain yield decreased with increasing irrigation.

3.8 Relationship between irrigation levels and water-use efficiency

The relationship between different irrigation levels and water-use efficiency was negatively correlated as shown in Figure 3. The highest water-use efficiency of 0.51 and 0.27 were both recorded from low irrigation level for the cultivars Emam and Condor, respectively. While the lowest values of 0.22 and 0.13 were obtained from the high irrigation level in both cultivars. Cultivars showed substantial difference in grain yield and water-use efficiency. Emam cultivar with higher grain yield tended to have higher water-use efficiency than Condor. This could indicate that higher yield cultivars have the potential to improve water use efficiency and thereby to save water [31].

4. CONCLUSIONS

The results of this study indicated that different irrigation level treatments and cultivars affected the water-use efficiency, growth and yield components of two wheat cultivars. Emam cultivar with higher grain yield tended to have higher water-use efficiency than Condor. Therefore, the increase in grain yield at high irrigation levels I_5 and I_4 compared to low irrigation treatment I_1 is about 48 and 42%, respectively. The results indicated negative relationship between grain yield and water-use efficiency. Water-use efficiency decreased with increasing irrigation levels. We recommend the irrigation level 1 ET "I_4" as the best management for optimizing wheat yield of Emam cultivar under tropical high terrace soil conditions.

5. ACKNOWLEDGMENT

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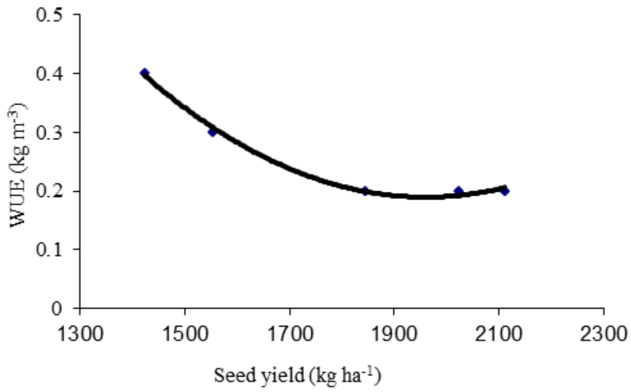

Figure 2: The Relationship Between Grain Yield and Water- Use Efficiency over Two Growing Seasons, (2009/2010 and 2010/2011)

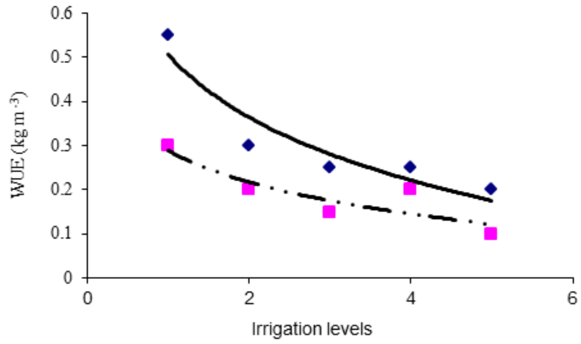

Figure 3: The relationship between different irrigation levels and water- use efficiency for two cultivars (Emam♦── and Condor ■─ ·· ─) over two growing seasons, (2009/2010 and 2010/2011)

6. REFERENCES

[1] Mustafa, R. H., Elgali, M. B. and Abulgasim, S. "Trends in wheat production and consumption in Sudan", International Journal of Research in Management, Economics and Commerce, vol. 3, no. 4, pp. 44-56, 2013.
[2] Konardeas, P. "Assessing Sudan's Export Diversification Potential in Agricultural Products," Maxwell Stamp PLC for the Ministry of Foreign Trade, Government of Sudan and the European Commission, 2009.
[3] Alsayim, H. E. and Saeed, A. B. Irrigation Principle and Practices, Nile Valley University, Sudan, 2013.
[4] Hatfield, J. L., Saauer, T. J. and Prueger, J. H. "Managing soils to achieve greater water use efficiency A. Review", Agronomy Journal(ACSESS), vol. 93, pp. 271-280, 2001.
[5] Allison, E. and Jones, C. "Plant water relations". Montana State University. Extension paper No. 4481-5.P.7. 2005.
[6] English, M. "Deficit irrigation. I. Analytical framework", Journal of Irrigation and Drainage Engineering(ASCE), vol. 116, pp. 399–412, 1990.
[7] Fereres, E. and Soriano, M. A. "Deficit irrigation for reducing agricultural water use", Journal of Experimental Botany(Oxford Journals), vol. 58, no. 2, pp. 147–159, 2007.
[8] Zhang, H. and Oweis, T. "Water–yield relations and optimal irrigation scheduling of wheat in the Mediterranean region", Agricultural Water Management(ELSEVIER), vol. 38, no. 3, pp. 195–211, 1999.
[9] Akram, M. "Growth and yield components of wheat under water stress of different growth stages", Bangladesh Journal of Agricultural Research(Bangladesh Journals Online), vol. 36, no. 3, pp. 455-468, 2011.
[10] Jin, M. G., Zhang, R. Q. and Gao, Y. F. "Temporal and spatial soil water management: a case study in the Heiloonggang region PR China", Agricultural Water Management(ELSEVIER), vol. 42, pp. 173–187, 1999.
[11] Wang, F. H., Wang, X. Q. and Sayre, K. "Comparison of conventional, flood irrigated, flat planting with furrow irrigated, raised bed planting for winter wheat in China", Field Crops Research(ELSEVIER), vol. 87, pp. 35–42, 2004.
[12] Zhang, B., Li, F., Huang, G., Cheng, Z. and Zhang, Y. "Yield performance of spring wheat improved by regulated deficit irrigation in an arid area", Agricultural Water Management(ELSEVIER), vol. 79, pp. 28–42, 2006.
[13] Allen, R. G., Pereira, L. S. Raes, D. and Smith. M. "Crop evapotranspiration, guidelines for computing crop water requirements", FAO Irrig. and Drain. Paper 56, Food and Agric. Orgn. of the United Nations, Rome, Italy. 300 pp. 1998.

[14] Voldeng, H. D. and Simpson, G. M. "Leaf area as an indicator of potential grain yield in wheat", Con. J. Plant Sci., vol. 47, pp. 359-365. 1967.

[15] Hussain, G., Al-Jaloud, A. A., Al-Shammary, S. F. and Karimulla, S. "Effect of saline irrigation on the biomass yield and the protein, nitrogen, phosphorus and potassium composition of alfalfa in a pot experiment", Journal of Plant Nutrition(Taylor & Francis Online) vol. 18, pp. 2389–2408, 1995.

[16] Steel, R. G. D., Torrie, J. H. and Dickey, D. A. Principles and procedures of statistics, A biometrical approach, 3rd ed. McGraw Hill book Co. Inc. New York, 400-428, 1997.

[17] Magsood, M., Shehzad, M. A., Ahmed, S. and Mashtaq, S. "Performance of wheat (*Triticum aestivum* L.) genotypes associated with agronomical traits under water stress condition" Asian Journal of Pharmaceutical and Biomedical Research(Literati Scientific and Publishers Pvt. Ltd), vol. 2, no. 1, pp. 45-50, 2012.

[18] Ali, M. H., Hoque, M. R., Hassan, A. A. and Khair, A. "Effects of deficit irrigation on yield, water productivity, and economic returns of wheat", Agricultural Water Management(ELSEVIER), vol. 92, no. 3, pp. 151–161, 2007.

[19] Ngwako, S. and Mashiqa, P. K. "The effect of irrigation on the growth and yield of winter wheat (*Triticum aestivum* L.) cultivars", International Journal of Agriculture and Crop Science(IJACS), vol. 5 no. 9, pp. 976-982, 2013.

[20] Khakwani, A., Dennett, M. D. and Munir, M. "Drought tolerance screening of wheat varieties by inducing water stress condition", Journal of science and technology(Prince of Songkla University), vol. 33 no. 2, pp. 135-142, 2011.

[21] Gholamreza, D., Askar, G., Amin, F., Behrouz, K. and Ezzat, N. "Effects of Drought Stress on the Growth, Yield and Yield Components of Four wheat Populations in different growth stages", Advances in Environmental Biology(AENSI), vol. 7, no. 4, pp. 619-624, 2013.

[22] El Hwary, A. B. A. and Yagoub, S. O. "Effect of skipping irrigation on growth, yield, yield components and water use efficiency of wheat (*Triticum aestivum* L.) in semi arid Region of Sudan", Agriculture and Biology Journal of North America, vol. 2, no. 6, pp. 1003-1009, 2011.

[23] Razia, R. and Chowdhry, M. A. "Genetic Analysis of Some Economic Traits of Wheat under Drought Condition", Asian Journal of Plant Sciences(Science Alert), vol. 2, pp. 790-796, 2003.

[24] Ghodsi, M. "Ecophysiological aspects of water deficit on water growth," Ph. D. Thesis on Agronomy. University of Tehran, Iran. 2004.

[25] Awad, A. M., El-Zaher, H., Moustafa, M. A., Sayed, M. A. and Osman, A. M. "Wheat production on sandy soils using different fertilization methods irrigation regimes", Alexandria Journal of Agric. Research, vol. 45, no. 1, pp. 35-61, 2000.

[26] Al-Tabbal, J. "Effect of water stress on the yield and yield component of durum wheat cultivars (*Triticum turgidum* L. Var. Durum)", International Journal of Academic Research(IPS LLC), vol. 3, no. 6, pp. 98-113, 2011.

[27] Huang, Y., Chen, L., Fu, B. Huang, Z. and Gong, J. "The wheat yields and water-use efficiency in the Loess Plateau: straw mulch and irrigation effects", Agricultural Water Management(ELSEVIER), vol. 72, no 3, pp. 209–222, 2005.

[28] Yagoub, S. O., Elkhalil, A. E. and Balasio, E. D. "Effect of different watering regimes on growth of two wheat (*Triticum aestivum* L.) cultivars at high terraces of North Sudan", International Journal of AgriScience, vol. 2, no. 8, pp. 684-695, 2012.

[29] Khan, M. J., Sarwar, T. Shahzadi, A. and Malik, A. "Effect of different irrigation schedules on water use and yield of wheat", Sarhad Journal of Agriculture, vol. 23 no. 4, pp. 1061-1066, 2007.

[30] Li, J., Inanaga, S., Li, Z. and Egrinya, E. A. "Optimizing irrigation scheduling for winter wheat in the North China Plain", Agricultural Water Management(ELSEVIER), vol. 76, pp. 8–23, 2005.

[31] Zhang, X., Chen, S., Sun, H., Wang, Y. and Shao, L. "Water use efficiency and associated traits in winter wheat cultivars in the North China Plain", Agricultural Water Management(ELSEVIER), vol. 97 no. 8, pp. 1117–1125, 2009.