Effect of Deficient Irrigation on Consumptive Use of Wheat (Triticum Aestivum.L) in Arid and Semi-Arid Areas

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Abstract— The experiment, located at the Yusufiyah region, 15 km South-West of Baghdad (44 o18'75" E and 33o07'84" N) (34.1 m above sea level), soil classified as Typic Torrifluvent as Silty Clay The objectives of the study were to test the response of wheat (Triticum aestivum.L) to limited irrigation under field conditions and to estimate Total actual water consumptive use and actual water consumptive use were studied during the growth stages, field water use efficiency and crop water use efficiency and yield were calculated.

A Randomized complete block design (RCBD) was used with three replications. Irrigation treatments includes complete irrigation as a control, deficient irrigation at tillering, elongation, flowering and grain maturity. Irrigation treatments were applied at 50- 55 % depletion from available water according to growth stages. .The cultivar was planted on 1/12/2017 and harvested on 20/5/2018.

Crop water requirements were calculated based on the soil water measurement by gravimetric method. Actual evapotranspiration was calculated from the soil water measurements measured for the 0-30 cm layer. The highest amount of applied water 430 mm was obtained under complete irrigation and it decreased to 356, 388,371 and 285 under limited irrigation during tillering, elongation, flowering and grain maturity respectively. Limited irrigation during the flowering stage gave the highest field and crop water use efficiency values of 1.33 and 1.27 K.g.m^{3-} . On the other hand, treatment limited irrigation during the elongation stage gave the lowest field and crop water use efficiency values of 1.08 and 1.18 K.g.m^{3-}

Index terms: Deficient irrigation, Consumptive use, Water use efficiency, Wheat.

INTRODUCTION

Water Resources occupies a distinguished place among the natural resources and play an essential role in human life and the environment. Water is the limiting factor for agricultural production in many parts of the world that suffer shortages of water resources. The rational use of water for irrigation of agricultural crops from the important issues in Iraq

Estimating the water needs of crops is one of the basic requirements when planning the land for agriculture and irrigation. The water needs of the crop depend on several factors, the most important of which are the prevailing climatic conditions, the nature of the crop, the variety, the soil type, the soil's ability to maintain the water and its other hydraulic properties. According to the addition of great importance as well as the importance of not causing significant water stresses on the plant or add excessive amounts of it during the irrigation process. deficient irrigation technology is a water management technique that increases the effectiveness of water use as it is used in field practices or by changing management schemes to minimize evaporation. The crop can be exposed to water stresses during the growing season or during specific growth stages that are more tolerant to these and this makes it possible to provide quantities of irrigation water, which leads to the introduction of additional agricultural areas without the need to provide new sources of water. One of the aims of deficient irrigation is to increase the efficiency of water use by removing the irrigation with the least effect in the final product (Hassan,2019).

Wheat is the world's number one cereal crop in terms of importance, cultivated area and global production, as a major food for more than a third of the world's population. Its importance is due to its containment of the protein, which is the basic protein to produce an appropriate quality for the bread industry (Jamali et al., 2000). Wheat in Iraq comes first in terms of cultivated area, which in 2015 amounted to about 1250000 hactars acres and a total production of 1.700 million tons with an average yield of 336.7 kg. Dunum (Directorate of Agricultural Statistics, 2015).

MATERIALS AND METHODS

A field experiment was carried out to cultivate the wheat rasheed cultivar during winter season 2017 - at the Yusufiyah region, 15 km South-West of Baghdad (44 o18'75" E and 33o07'84" N) (34.1 m above sea level), soil classified as Typic Torrifluvent as Silty Clay The chemical and physical properties of the study soil were estimated table(1)

Table.1: Physical and Chemical properties of Experimental Soil

Characteristic	Soil depth 0-30 cm
EC (dsm^{-1})	3.2
PH	7.6
Sand%	120

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Silt%	g/kg	620
Clay%		260
Textural class		Silt clay

CEC (mole.kg^{-1})		23.31
N%		0.0021
P	Mg/Kg	35.2
K		62.13
$CaCO_3$	Mleq.L^{-1}	28.0
Ca		16.15
Mg		7.51
Na		12.88
K		1.63
CO_3		Nil
HCO_3		1.95
Cl		20.22
Organic Matter%	%	4.50
Bulk Density	Mg/M^3	1.38
Particle Density		2.58
Porosity	%	48

Preparation of soil experiment

The soil of experiment was plowed by the tearing plow and the adjustment was made. Divide the field into 2 m x 2 m panels, leaving a comma between the experimental units with a distance of 1.5 m and repeaters with a distance of 1.25 m to ensure that the water does not move from one plate to another. The field was divided into three main sectors and each sector was divided into 15 experimental units. There were five irrigation parameters. The experiment was designed according to the design of the complete random sections RCBD.

Planting and fertilization

The seeds of wheat (Triticum aestivum L.) were planted on 1/05/2017, in the form of the lines between the line and the last 20 cm seeds were added at a rate of 140 kg seeds. Nitrogen fertilizer was added to experimental units at a rate of 200 kg urea (46% N). E. The quantity was divided into two equal batches, the first after planting, up to three weeks, and the second at the beginning of the forest. Superphosphate fertilizer was added by 100 kg P2O5 e1 - one batch before smoothing (Abu Dhahi, 1988). Potassium fertilizer was added in potassium sulfate form K2SO4 (41.5% K). Potassium fertilizer was divided by four equal batches according to plant growth stages, elongation, flowering and maturation.

Deficient irrigation treatment

The deficient irrigation process (limit two irrigation not respectively) was carried out for each stage of growth of the wheat plant, which is the tillering, elongation, flowering and maturation phase. Upon reaching the specific growth stage, after depletion (50-55%) of the prepared water is calculated by weight method.

Moisture Measurement and Water Management

The first irrigation (Germination Irrigation) was applied until saturation limits to be available soil moisture for encourage seeds germination.

The sequent irrigation was applied during the growing season on the basis of moisture depletion of 0.30 m depth. Soil moisture was monitored on a weekly by the gravimetric method (weight basis) for each plot which is calculated as:

$$(\Theta W) = \frac{Wet\ wt - Dry\ wt}{Dry\ wt}\ x\ 100 ------(1)$$

Where:

ƟW is soil moisture percentage, Volumetric water content (ƟW) in percentage corn be calculated if the soil bulk density(Pb)

$$(\Theta v) = \frac{Wet\ wt - Dry\ wt}{Dry\ wt}\ x\ 100\ x\ Pb ------(2)$$

$$\Theta v = \Theta W\ x\ Pb ------(3)$$

The amount of water in soil can be expressed in depth per unit soil depth

Depth (cm) water per unit soil depth

$$(D_S) = \Theta v\ x\ DS ----(4)$$

Ɵv= volumetric water content

DS= water per unit soil depth

The water volume that must be added to any experimental plot is calculated and based on the following relationships:

$$Wv = DSx\ A ------(5)$$

where:

Wv = water volume

DS= Depth water per unit soil depth

A = experimental unit area

Irrigation scheduling (to repent) after soil moisture depletion (40- 50 %) of available soil moisture in 0 – 30 cm soil depth of different growth stages, available water (Avw) was calculated based on the following relationships:

$$Avw = \Theta FC - \Theta W ------(6)$$

where:

Avw = available water of soil (0- 30 cm depth)

ƟFC = volumetric water of field capacity

ƟW = volumetric water of wilting point

The evapotranspiration

(ET) of individual plots of maize for the entire growing season was estimated by the standard water balance equation (Allen et al. 1998)

ET = (P+I+C) - (RO + DP) ± ∆S …………….(7)

where:

∆S = The change in soil water storage before sowing and after harvest measured in the profile (mm)

P= The precipitation (mm)

I = The irrigation (mm)

C= Up ward flow into the soil profile (mm)

RO = The surface Runoff from each plot (mm)

DP = The deep percolation out of the soil profile (mm)

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P= Zero there was is no precipitation during the growing season

C= Zero Because the ground water table remained at a depth of about 3 m below the surface

D= Zero Because as irrigation water was added at field capacity limits.

R= Zero Because as irrigation water was protected by 40 cm high bunds.

ΔS = Zero Because the soil water storage before sowing ≈ soil water storage after harvest.

Water use efficiency

Water productivity was determined by dividing grain yield by evapotranspiration as following (Howell,2003)

$$\mathbf{WP} = \frac{\mathbf{GY}}{\mathbf{ET}} \quad ----- \quad (8)$$

Where:

WP = Water productivity (Kg / m^3)

GY = Grain yield (Kg / ha)

ET = Corn total water consumption of the growing season (m3 / ha)

Productivity of irrigation water was calculated as (Howell,2003)

$$\mathbf{PIW} = \frac{\mathbf{GY}}{\mathbf{I}} \quad ----- \quad (9)$$

Where:

PIW = Productivity of irrigation water

GY = Grain yield (Kg / ha)

I = Irrigation water applied (m3 / ha)

Crop coefficient (Kc)

According to the yield coefficient (Kc) of wheat yield from the following equation (Allen et al., 1998)

Kc = ETa / ETo ……………………(10)

Where:

ETa: Actual evaporation-transpiration (mm)

ETo: Evaporation-Nectar Reference (mm)

Kc: Crop coefficient (without units)

(Coefficient of response (Ky)was calculated as (Stewart et al. 1977

Ky = (1-Ya / Ym) / (1-ETa / ETm …………..(11)

Where:

Ky = response response coefficient.

Ya= Actual production (ton / ha)

Ym = the highest production at the highest evaporation-nit (ton / ha

ETa = evaporation-actual transpiration (mm

ETm = Evaporation - Maximum Nucleus (mm

1-Ya / Ym = the percentage of the decrease in the sum

RESULT AND DISCUSSION

The actual water consumption

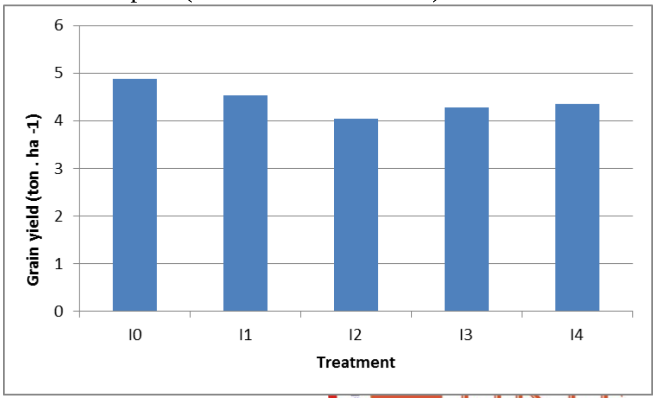
The results in Table (2) show the depth of the added water and The actual water consumption during the wheat crop growth season for the complete irrigation treatments (I0) and the deficient irrigation (cutting tow irrigated during each stage of growth) for the winter season 2017-2018. The total irrigation treatment showed the highest water value added to complete irrigation it was 430 mm for the season and was reduced to 356, 388, 371 and 353 mm for the deficient irrigation treatments (I1, I2 ,I3 and I4) Which is higher than the rest of the deficient irrigation treatments, due to the fact that the irrigation water additions were higher in the irrigation treatment due to the increase in the number of irrigation, which amounted to 12 number of irrigation while the irrigation limited to 10, due to the increase in the consumption rate The plant is waterproof by increasing moisture content of the soil as a result of increasing the amount of irrigation water added (20.7%, 10.8%, 15.9%, and 21.8%) for deficient irrigation treatments at the tillering, elongation, flowering and grain maturity levels, respectively, compared with the complete irrigation treatment, and these results are consistent with (Abedinpour .2017 and Hassan,2016) he found Elongation, flowering and grain growth have reduced the water requirements of the plant and provided an important amount of irrigation water amounting to 11-14% compared to the full irrigation treatment 431 mm.

Table (2): Quantity of water added and water consumption of wheat crop for various transactions.

Treatment	ETa mm	Rain mm	ETcmm	Number of Irrigation
I0	461	31	430	12
I1	387	31	356	10
I2	419	31	388	10
I3	402	31	371	10
I4	384	31	353	10

Grain yield (ton . ha $^{-1}$)

Figure (1) showed that irrigation coefficients did not cause a significant decrease in grain yield and in all stages of growth compared to complete irrigation treatment, except irrigation treatment during the elongation period, in which the yield decreased significantly and achieved a mean average yield of 4.043 tons. The decrease was 8%, 20.8%, 14.2%, and 12.2% for irrigation cuttings during the stages, elongation, flowering and grain maturity respectively, compared with the complete irrigation treatment which achieved the highest average of 4.885ton.ha-1. The decrease in the elongation phase is due to the fact that the water stress reduced the number of spikes per square meter, the number of grains per spike and the weight of the grain, because at this stage the development of the branches bearing Spike is determined as well as the emergence and development of the saplings. The water pressure can also reduce the number of grains in the spike (Abdul-Jabbar. et.2016)



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Figure(1) Grain yield (ton . ha -1)

Biological yield (ton.ha^{-1})

The results of Figure (2) showed that the irrigation and irrigation parameters did not include any significant differences in the biological yield, and the water stress effect varied according to the different stages of growth. The complete irrigation treatment gave the highest mean of the biological yield of 13.531ton.ha-1. In the stage of grains of maturity, the average yield of the grains was less than 12.068 ton.ha-1. The growth stages can be arranged according to the intensity of their effect in the watercourse and the maturity of the grains.> Elongation> Flowering> The decline in the biological yield of the deficient irrigation treatments are 3.7, 10.9, 7.9 and 12.12% for deficient irrigation over the years Solution to the tillering and elongation and flowering and maturation of grains, respectively, compared to the treatment of full irrigation.

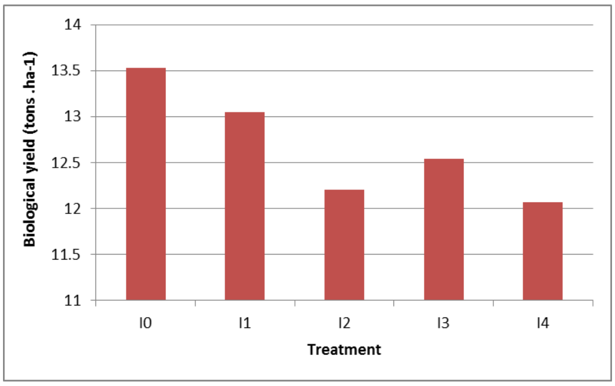

Figure (2) Biological yield (ton.ha-1)

Plant height (cm)

Figure (3) showed that the superiority of full irrigation treatment significantly on the treatment of deficient irrigation during the phases of elongation and flowering, achieving the highest average height of the plant was 92.3cm while the average height of the plant during the phases of elongation and flowering 88.5 and 88.1 cm respectively, The results showed that the treatment of deficient irrigation during the two stages and the maturity of the grain did not differ significantly from the treatment of the complete irrigation The percentage of reduction of the deficient irrigation treatments during the stages of the tillering, elongation, flowering and grain maturity was 3.4, 5.8, 6.2 and 1.4% compared to complete irrigation, effect of water stress in plant height during Solution elongation and flowering These findings are consistent with (Latif .et. 2016) from the water tension during the vegetative growth phase led to reduced plant height due to the impact of water tension in the division and cell elongation

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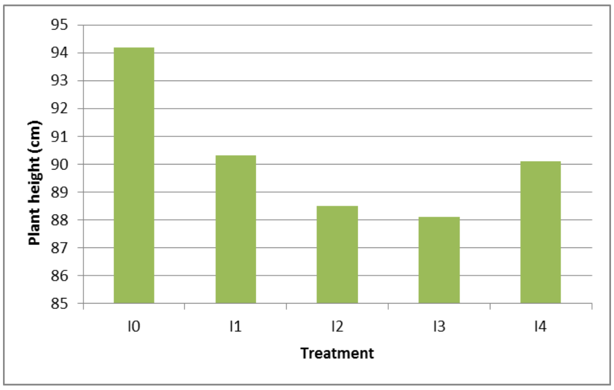

Figure (3) Plant height (cm)

Water use efficiency crop and field (kg.m^{-3})

Figure (4) showed The results of water use efficiency of field and crop calculated during the stages of wheat growth and the effect of irrigation treatments , where the efficiency values of field and crop water use were different. This is due to the fact that the quantity of water requirements added to the field is not equal to the actual water consumption of the crop and to all the full and deficient irrigation treatments due to the contribution of ground water to evaporation values. The irrigation treatment during the tillering phase gave the highest value for the efficiency of field and crop water use of 1.27 and 1.16 (kg.m-3). The irrigation treatment during the elongation phase gave the lowest value of the field and crop water use efficiency of 1.04. 0.96 (kg.m-3). figure (4)shows that the efficiency values of field and crop water use for irrigation deficient irrigation during the tillering stages and grain maturity are greater than their values for complete irrigation , elongation and flowering treatment irrigation. The reason was that the plant was not exposed to water stress and did not significantly affect the grain yield, which showed the results in Table (3). There were no significant differences between the complete irrigation and the deficient irrigation except for the irrigation treatment during the elongation phase, thus increasing the efficiency of field water use and crop. This finding was consistent with (International Telecommunication Union. 2015) and Brihma et al (2011) found that increasing the irrigation led to a reduction in water use efficiency, while irrigation at the sensitive elongation stage gave the lowest value for field and crop water use efficiency.

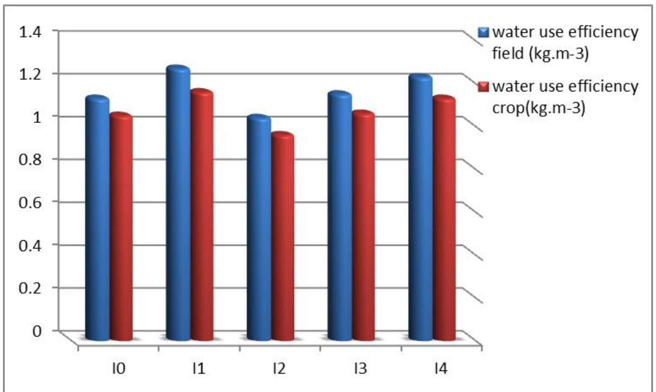

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Figure (4)Water use efficiency crop and field (kg.m^{-3})

Yield coefficient Kc

Figure (5) shows the values of the yield coefficient Kc for complete irrigation and deficient irrigation during the growth stages of the wheat crop, tillering ,elongation ,flowering and grain maturity. The average yield coefficient ranged between 0.26 and 0.96 and gave the complete irrigation treatment the highest average yield value of 0.96. While the low value in tillering was 0.26. The increase in the value of the crop coefficient for the complete irrigation treatment was due to the increase in the actual water consumption of this treatment during the season compared to the deficient irrigation treatments. this results concurred with this finding with Hossain (2012) . The results were also agreed with the results of Ati study (2014). The use of deficient irrigation in the stages of tillering ,elongation ,flowering and grain maturity of the wheat plant compared to the complete irrigation treatment showed in the crop coefficient values, It is also noted from Figure (1) that the lowest value of the crop coefficient in the deficient irrigation coefficients was for the treatment during the tillering. This is due to the decrease in the value of water consumption and the decrease in temperature at the beginning of the growth season, which reduced the amount of evaporation during the period until the water consumption reached 387 mm, Table (2) and thus increase the value of the yield coefficient Husman et al. (1999)and Hassan,2018.

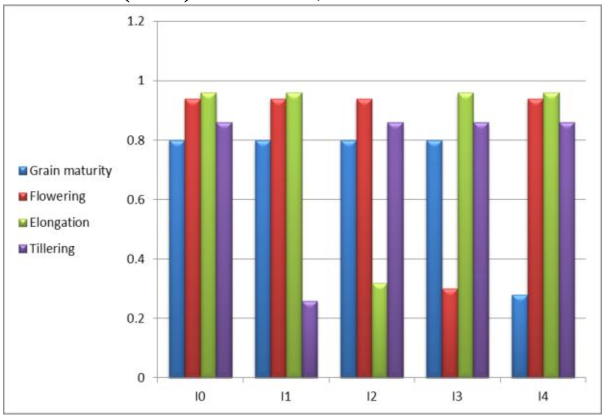

Figure (5) Yield coefficient Kc

yield coefficient Response (Ky)

Deficient irrigation causes water stress when it occurs during any stage of plant growth. In order to quantify the effect of water stress in the plant, it is necessary to find the relationship between the relative decrease of 1-(Ya / Ym) and evaporation deficit 1-(ETa / ETm). When water stress occurs, the relative evaporation of evaporation tends to be higher than the relative decrease in the yield. High yield coefficient (Ky) is therefore expected. The yield response coefficient expresses the plant's sensitivity to the water stress in the soil. The plant's response to water shortage varies during its different stages of growth Figure (6) shows the difference in the values of the wheat yield response (Ky) in different stages of growth. The highest value in the elongation phase was 1.8. The sensitivity of wheat to water stress can be arranged in different stages of growth such as elongation> flowering> grain maturity> tillering . This can be observed from values (Ky) that are greater than one. This means that the loss of the sum is more important than the lack of ET (Kirda and Kanber, 1992). This can be explained by the fact that the exposure of wheat plant to water stress during the elongation phase affects mainly the division and elongation and differentiation of cells, which leads to the occurrence of changes in appearance, such as the emergence of leaves, buds, saplings, pollination and fruits. All processes occurring in the plant are affected by water shortage that not only reduces the overall growth rate but also changes the shape and nature of that growth (Fahad,2011) . When the plant is subjected to water stress, it may negatively affect the shape and body of the leaves and the expansion of the cells and reduce the paper area and close the gaps, which leads to a reduction in the rate of photosynthesis and increase breathing and reduce net representation, causing a decrease in the incidence (Lauer and Boyer, 1992). Water stress during the development stage of leaves and stubs reduces the development of leaves, broilers and the number of grains of spike in the elongation phase and thus reducing the yield (Tali, 2014).

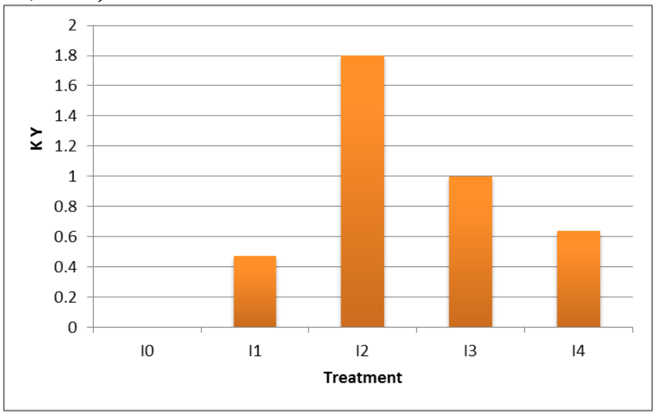

Figure (6) yield coefficient Response (Ky)

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