Bionatura
Latin American Journal of Biotechnology and Life Sciences

Type of the Paper (Article)

Estimation of water consumption of maize under climatic conditions of middle Iraq

Jamal Naser Abdel al rahman Alsadoon[1], Haidar Abd al Mahdi Kadim[2] and Mustafa Iskander Zaid Al-Wardy[2]

1 Wasit University / College of Agriculture; Jnaser@uowasit.edu.iq.
2 Wasit Agriculture Directorate; mustafaesknder2020@gmail.com.
* Correspondence: mustafaesknder2020@gmail.com.
Available from. http://dx.doi.org/10.21931/RB/2023.08.03.129

ABSTRACT

Field experiment was conducted at season 2018 in central Kut district in Wasit Province, Iraq, with four treatments and three replicates in a randomized complete block design (RCBD) to evaluate the response of maize to different irrigation levels irrigated by basin-irrigation method. Irrigation water was applied as 50%, 75% 100% and 125% of evaporation from a Class A Pan. The results indicated that the highest ETc , total ETa and grain yield were found in 125% Epan (716.7 mm, 799.2 mm and 9.600 t. ha^{-1}) respectively. While the lowest were found in 50% Epan. The highest water use efficiency (WUE) was found in Irrigation level (75% Epan) as (1.402 kg. m^{-3}), and the lowest was found in irrigation level (125% Epan) as (1.202 kg. m^{-3}).

Keywords: Irrigation levels, Ep%, ET, water consumption, grain yield and WUE of maize.

INTRODUCTION

The irrigation studies have made great achievements on improving the efficiency of water and ensuring food security, but still has great potential for improving water use efficiency in many field crops [6]. Water is one of the most important factor affecting crop production and its movement through the soil-plant atmosphere [13]. Water is an important natural resource and its increasing scarcity has led to concerns for its efficient use, management, and sustainability [8] When irrigation is required there are many available methods and management strategies. The selection of the method and approach depends on factors such as water availability, crop type, soil characteristics, land topography, and associated cost [12]. Water shortage is one of the main constraints for economic development in arid and semi-arid areas. However, it is very important for these areas to promote public awareness as regards water-saving measures so as to develop the social sustainability and extension of new cultivated areas [10]. Water scarcity and drought are the major factors constraining agricultural crop production in arid and semi-arid zones of the world. Irrigation is today the primary consumer of fresh water on earth. Therefore, innovations for saving water in irrigated agriculture and thereby improving water use efficiency are of paramount importance in water-scarce regions [21]. Scientists from all over the world look to the studies correlated to water use efficiency (WUE) which is an important measure that shows the relationship between the unit dry matter produced and unit of water used. Thus, water use efficiency (WUE) is one of the ways to analyze the response of crops to different conditions of water availability as it relates to the production of dry biomass or commercial production with the amount of water applied evapotranspiration or by culture [14]. Evapotranspiration (ET) is the combination of two different processes where water is lost from the soil surface and from the surface leaves by evaporation and from plants by transpiration. [19]. The crop coefficient (K_c) is defined as the ratio between the actual crop evapotranspiration (ET_a) and the reference evapotranspiration (ET_0). [5]. indicated that there was linear relationship between grain yield of maize and seasonal irrigation water amount. Maize (Zea mays L.) is the third most important cereal crop in the world after wheat and rice [4]. Maize requires 600-700 mm water for optimum growth and yield depending upon climatic conditions. [11].

The objectives of this study are to: determine the effect of irrigation levels during growing season on production of maize; and evaluate the water use efficiency of basin-irrigated hybrid corn planted in the area middle Iraq.

MATERIALS AND METHODS

Experimental *site*

A field experiment by basin-irrigated maize was conducted in central kut nursery, Wasit Agriculture Directorate at season 2018 under ecological conditions of Kut district in Wasit Province, Iraq. Soil samples were taken with an auger from soil layers of 0 – 10, 10-20, 20-30 and 30-40 cm to determine selected chemical and physical properties of the experimental field, [17] are summarized in (Table 1). Moreover, some useful climatic data of the experimental site was obtained from the Iraq Agrometeorological Network, Kut station. (Table 2).

Table 1 chemical and physical characteristics.

Measured Character		Value	measuring unit
pH		7.8	
Electrical conductivity (EC)		4.4	dsm^{-1}
Nitrogen		15	$mg\ kg^{-1}$
Phosphorus		12	
Potassium		189	
Soil components	Sand	440	$gm\ kg^{-1}$
	Silt	200	
	Clay	360	
Soil texture		silty clay	

Table 2. Climate data of the season 2018 for the Iraq Agrometeorological Network, Kut station.

Month	Rain mm	T Max C^0	T Min C^0	RH Max %	RH Min %	WS Avg. $msec^{-1}$
Aug	0.00	44.63	28.70	29.84	8.44	2.65
Sep	0.00	43.59	25.83	32.35	7.72	1.73
Oct	33.4	35.60	19.86	61.33	19.36	1.38
Nov	50.1	22.62	11.55	89.41	47.02	1.25

Experimental *design and treatments*

The experiments were conducted using a randomized complete block design with three replications, the area of each plot was 6 m2. The irrigation treatments considered in the study were basin irrigation equivalent to 50% (I_1), 75% (I_2), 100% (I_3) and 125% (I_4) of evaporation from a Class A Pan (Epan).

Agronomic practices

The maize hybrid (kalimeras) was planted at a spacing of 0.25 m × 0.75 m at 5 August 2018. All treatments plots received the same amount of fertilizer application at rates of 300 $kg.ha^{-1}$ DAP (Di Amino Phosphate, 18:46:0), were applied uniformly to the field before planting, and this was followed by, 320 $kg.ha^{-1}$ in form of urea (46% N), which was applied in banding along the rows on two doses, first when six leaves appears and second after 30 days of the first dose.
Weeding was done manually when required to save undue losses of nutrients and soil moisture. The harvest at 20 November in 2018, random samples of five guarded plants for each experimental unit were taken, and grain yield (GY) was determined per each experimental unit then converted to GY $t.\ ha^{-1}$.

Irrigation practices and methodology

Water were applied to all irrigation treatment plots at same time using a basin irrigation method. Irrigation intervals were determined according of evaporation from a Class A Pan. Thereafter, irrigation treatment was started according to the prescribed irrigation rates and the irrigation water requirement to each plot during the entire growing season was calculated by using the following equation [2]*:*

$V = a \times d$ ------------- (1)

where: V= Volume of added irrigation water (m^3), a = Area of experimental unite (m^2), d= Irrigation depth (mm), equal to depth of evaporated water from evaporation pan (Ep).

The time of irrigation calculated by using the following equation (2):

$t = a\ d / Q$ -------------(2)

where: t= Irrigation time (h), Q= Discharge irrigation water ($m^3. h^{-1}$).

Reference evapotranspiration (ET_0) was determined from evaporation pan (class A pan) was installed near the research site to record daily evaporation pan computed by following equation (5):

$ET_0 = K_p \times E_{pan}$ ------------- (3)

Where: Epan is evaporation from the class A pan (mm. day^{-1}), Kp is the pan evaporation coefficient.

The pan evaporation method measures the evaporation from the open water surface, taking into account cumulative effect of radiation, wind, humidity and temperature. The applied irrigation water amount was calculated based on the depth of evaporated water from evaporation pan (d) according to equation (1), the actual Evapotranspiration (ETa) was calculated by using the reference evapotranspiration (ET_0) and the crop coefficient (Kc), according to equation (4)

Where: ETa: actual Evapotranspiration (mm. day^{-1}), Kc crop coefficient.

The Kc values of maize used (0.5, 1.25, 1.35, and 0.86, at the germination, vegetative growth, flowering and maturity stages, respectively) (6).

Water use efficiency (WUE) was computed as the ratio of maize grain yield to volume of added water according to following equation (21):

$WUE = Y / W$ ----------- (5)

Where: Y: total grains yield (kg. ha^{-1}), W: volume of added water ($m^3. ha^{-1}$*).*

Statistical analysis

The data analysis were performed using GenStat program and mean comparison were carried out by using the least significant difference (LSD) test at probability levels of 0.05.

RESULTS

The results illustrated in (Table 3) showed the effect of irrigation levels under basin irrigation method on crop evapotranspiration (ETc) of maize, the highest ETc value was (716.2 mm) observed when using 125 % of evaporation from a Class A Pan. Meanwhile, the lowest value was (381.8 mm) obtained with 50% of evaporation from a Class A Pan under basin irrigation method. Similar findings are reported by (3).

Data in Table (3) indicated the effect of irrigation levels on actual evapotranspiration (ETa) of maize crop. Results illustrated that the highest ETa value was (798.7 mm) observed when using 125 % of evaporation from a Class A Pan. While the lowest value was (464.3 mm) obtained with 50% of evaporation from a Class A Pan. Similar result was concluded by (7) and (20).

Irrigation levels affected the grain yield of maize crop significantly (Table 4). Maximum grain yield (9.600 t. ha^{-1}) was obtained when irrigation was applied at 125% of evaporation from a Class A Pan. Minimum grain yield (6.440 t. ha^{-1}) at 50 % of evaporation from a Class A Pan. Similar results have been reported by (7), and (18).

water use efficiency (WUE) was affected by different irrigation levels (Table 4). Highest and lowest water use efficiency of irrigation levels I_2 and I_4 (1.402 kg. m^{-3}) and (1.202 kg. m^{-3}) respectively. These results are in agreement with those of (1) and (16).

Table.3. Effect of irrigation levels on the average ET_C and ETa of maize during the season 2018.

Treatments	Irrigation number	ETc mm	Volume of added water m^3. ha^{-1}	Rain	ETa mm	Total volume of added water m^3. ha^{-1}
I_1	15	381.8	3818	82.4	464.3	4643
I_2	15	493.0	4930	82.4	575.5	5755
I_3	15	604.6	6046	82.4	687.1	6871
I_4	15	716.2	7162	82.4	798.7	7987
LSD (0.05)		5.195			3.300	

Table.4. Effect of irrigation levels, on the average grain yield, WUE of maize during the season 2018.

Treatments	Grain yield (ton ha^{-1})	WUE (Kg. m^{-3})
I_1	6.440	1.387
I_2	8.070	1.402
I_3	9.420	1.371
I_4	9.600	1.202
LSD (0.05)	1.061	0.141

DISCUSSION

In this study, evaluated the effects of irrigation levels and strategies on yield of the basin-irrigated maize crop was planted under the climatic conditions in middle Iraq in 2018.
Irrigation levels had a statistically significant impact on the grain yield, ET and WUE. Applying the correct amount of water is particularly critical for crops that are sensitive to water stress. Therefore, the total amount of water applied to plants during the entire growing period was important [15]. Furthermore, that the a linear relationship existed between seasonal water use and grain yield, also the declines in dry matter and grain yields could be attributed to an increased soil water deficit [20].
Decreased irrigation amounts applied in deficit irrigation treatments. Consequently, relatively yield reduction [7]. On the other hand, the WUE values increased with the decreasing seasonal irrigation amounts or seasonal water use [18].Hence, the higher values of water use efficiency observed under water stress treatment as compared to normal irrigation as shown in Table (3 and 4). Eissa et al. (2017) explained that the increase in irrigation water to 100% of water requirement increased the plant growth, nutrients uptake and this lead increased grain yield of maize[22,23].

CONCLUSION

Based on the results of this research:It can be concluded that the (ETc) were (381.8, 493.0, 604.6 and 716.2 mm). While that the total (ETa) were (464.3, 575.5, 687.1 and 798.7 mm) for irrigation levels (50%, 75%, 100% and 125% of Epan), respectively This study evaluated the effect of different seasonal irrigation amounts on maize evapotranspiration, grain yield and crop water use efficiency, On the other hand, irrigation level 100% and 125% of Epan gave the highest grain yield as about (9.420 and 9.600 t. ha^{-1}), respectively The highest water use efficiency (WUE) was 1.402 kg.m^{-3} at 75% of Epan.The results of this research indicated that irrigation with 100% and 125% of Class A pan evaporation by a basin irrigation method would be optimal under adequate water source conditions.

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Received: 25 June 2023/ Accepted: 26 August 2023 / Published:15 September 2023

Citation: Jamal A.; Haidar K .; Mustafa A. Estimation of water consumption of maize under climatic conditions of middle Iraq. Revis Bionatura 2023;8 (3) 129 http://dx.doi.org/10.21931/RB/2023.08.03.129