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Mitigating Drought Impact in Corn Cultivation Using Different Drip Irrigation Techniaues

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Abstract

The excessive use of irrigation water led to thinking about creating new irrigation techniques to take full advantage of water input, whereby the agricultural drought will be reduced. For this purpose the current study was carried out to adopt modern irrigation techniques by manipulating traditional drip irrigation technique at depth 0, 5, 15, and 30 cm (DI, SD_{I5}, SDI_{15}, SDI_{30}) and basket technique at depth 5, 15, and 30 cm (BT_5, BT_{15}, and BT_{30}) for irrigating corn plant under two levels of irrigation for receiving 100% and 65% of depleted water (I_1 and I_2, respectively). The grain yield and the amount of consumed water were estimated to calculate irrigation water use efficiency (IWUE) and yield response factor (K_y). The cumulative depth of irrigation with precipitation for I_1 and I_2 were 781 and 606 mm, respectively. The grain yield of corn has been significantly ($p \leq 0.05$) influenced by level and technique of irrigation; the level I_1 and the technique SDI_{15} showed the highest values. Also the maximum IWUE among all techniques in both irrigation levels was for SDI_{15}, while the minimum IWUE was for DI. The yield response factor showed no significant difference ($p \leq 0.05$) among all techniques except the DI which gave the highest value 1.381, while the lowest value of 1.093 recorded for BT_5. In this study, K_y values in all drip irrigation techniques were bigger than one; In this case using degree of soil water stress (K_s) less than 0.74is not preferable and mitigating drought impact in corn cultivation is unsuccessful.

Introduction

Climate change and population growth are making the irrigation accounts for two-thirds of water use worldwide from rivers and aquifers. Therefore, water resources in many parts of the world are pushed to their natural limits (drought). In other words, the adequate food and water cannot be guaranteed for the current and next generations, due to the water shortage and uncertain maintenance of the natural resources [1]. Despite the drought problems, irrigation has still a vital importance in providing foods and employmentsfor growing populations worldwide. The drought can be defined as the absence of enough moisture essential for normal plant growth and to complete the life cycle [2].Since the drought is unpredictable phenomena (both in their occurrence and duration), prevision and preparation against it are key elements for minimizing its adverse impact [3].Accordingly, the agriculture development strategies of most countries have led to think about adopting modern irrigation techniques in orderto improve IWUE and consequently mitigating impacts of water shortage and drought problems.

As referred by Smeal (2007) [4] drip irrigation is the slow application of water above the soil surface or underneath by *DI* or *SDI*. Currently, this technology is the most effective system for water and energy consumption. Surface drip irrigation is the way to convey directly water and nutrients to plants. While, *SDI* system is designed for deliver water and nutrients directly to the root zone[5]. This procedure reduces soil water evaporation losses especially in low population density of the crops [6, 7]. Although *SDI* has high

IWUE and numerous advantages, its expansion is quite limited. The reasons of its limited use are; high cost, emitters clogging and breakage problems by roots or solid particles, and the difficulty of detecting and repairing potential leakage problem [8]. To avoid most of these drawbacks, basket technique has been developed. It consists of installing the water distribution network and the emitters on the soil surface, while the emitters discharging into a perforated plastic pipe vertically inserted into a hole in the ground [6]. In this way, the wet area is formed at subsurface of the soil which depends on pipe depth, just at the bottom end of the perforated pipe. When the perforated pipe has deep depth with a small enough diameter, the evaporation losses can be negligible [9].Aoda and Fattah (2011) [10] showed that the purposes of the modern irrigation system techniques with applying deficit irrigation are to increase *IWUE*, to conserve water, and to limit leaching then reduce groundwater pollution hazards. Groundwater is an important part of the natural resources which can be realized in areas where supplementary irrigation is mostly required such as the Kurdistan region of Iraq. Kirda (2002)[11] defined deficit irrigation as the practicing of limited irrigation, the level of soil water status within the plant root zone is less than what would be under full irrigation, as a result actual evapotranspiration (ET_a) falls below maximum evapotranspiration (ET_m). Under such conditions, water stress will develop in the plant, which will adversely affect crop growth, and therefore the yield will be less than the maximum yield. Deficit irrigation has various features depending on how, when, where, and why it is administered [12]. A very interesting aspect of water use by plants is to determine how soil water content affects evapotranspiration, crop yield, and *IWUE*. In other words, to what extend the soil dry must be before limits evapotranspiration, crop yield, and *IWUE*? Payero et al (2009) [13] reported linear increases in yield and *IWUE* with increasing soil water stress coefficient (k_s). The closer k_s value to 0.5, the most probability of plants wilting, or the growth and yield components will be greatly affected [14; 15; 16]. Khorshidi and Nasseri (2011) [17] summarized that although a significant decrease in yield was observed with decrease of ET_a/ET_m (k_s) but an acceptable crop yield could be obtained using an irrigation program on the basis of $0.8 < ET_a/ET_m$. Also Klocke et al (2010) [15] reported that maintaining a water deficit ratio (deficit irrigation/full irrigation) is greater than 0.7 to 0.8.

Irrigation water use efficiency (IWUE*)* and K_y are a good indicator for evaluating the limited irrigation management with achieving the highest possible economic return [18]. Irrigation water use efficiency is generally used to express the ratio of total dry matter production to amount of irrigation water and it is influenced by a variety of factors, such as crop type, atmospheric environment, cultivation practices, soil conditions [19] irrigation water management practices [20]. Fattah (2009) [18] advocated that the efficient water use is performed by optimizing water use. Singh and Singh (1995)[21] pointed that efficient water use means optimizing water usage and ensuring efficiency in its use. On the above perspective, the water use efficiency can be improved either by increasing the numerator (crop yield) or decreasing the denominator (evapotranspiration), depending on availability of suitable land or water.Limited irrigation will presumably decrease crop yield, therefore for an area where land is not limited as like as water (semi-arid areas), emphasis should be given to the developing systems that reduce all water losses other than transpiration which is possible with less frequent irrigation.

The equation of $K_y$was formulated by Stewart to estimate the relationship between crop yield and water use (relative reduction in yield is related to the corresponding relative reduction in evapotranspiration) [22]. Yield response factor (K_y) varies depending on species, variety, irrigation method and management, and growth stage when deficit evapotranspiration is imposed; if the value of K_y is more than 1.0 that means the relative reduction of grain yield under deficit irrigation will be higher than the relative reduction of evapotranspiration [11]. Also, Doorenbos and Kassam (1980) [23] stated that, when $K_y< 1$, yield loss is less important than evapotranspiration deficit; when $K_y> 1$, yield loss is more important than evapotranspiration deficit and when $K_y = 1$, yield loss is equal to evapotranspiration deficit.Based on the tremendous amount of the available literature on crop-yield water relationships and deficit irrigation, K_y values (Table: 1) were derived for several crops [22].

Deficit irrigation had more adverse effects on the yield by using traditional irrigation system than modern ones [18]. Therefore, updating of K_y for different crops is necessary, as parallel to the developing of irrigation techniques the management of irrigation will be improved, such as the reduction of soil water evaporation. As ET_a combines soil evaporation and plant transpiration, it may be necessary to identify each of these components because dry matter elaborated by crop photosynthesis is only directly linked to the second component [24]. The objective of this investigation was to compare the effect of different drip irrigation techniques (DI, SDI, and BT) under two levels of irrigations on confronting agricultural drought for corn plant using IWUE and K_y as an indicator.

Table-1: Seasonal K_y values from irrigation and Drainage paper No. 33; FAO (Doorenbos and Kassam, 1980) [23].

Crop	K_y	*Crop*	K_y	*Crop*	K_y	*Crop*	K_y
Groundnut	*0.70*	*Cabbage*	*0.95*	*Potato*	*1.10*	*Spring wheat*	*1.15*
Safflower	*0.80*	*Sunflower*	*0.95*	*Alfalfa*	*1.10*	*Peas*	*1.15*
Cotton	*0.85*	*Sugarbeet*	*1.00*	*Onion*	*1.10*	*Sugarcan*	*1.20*
Soybean	*0.85*	*Tomato*	*1.05*	*Pepper*	*1.10*	*Maize*	*1.25*
Sorghum	*0.90*	*Winter wheat*	*1.05*	*Watermelon*	*1.10*	*Banana*	*1.30*

Materials and Methods

A field experiment was conducted on 23rd July 2015at the research station of the College of Agricultural Engineering Sciences, University of Sulaimani. The study area is located in the west of Sulaimani city (Latitude: 35º 34' 19" N; Longitude 45º 22' 02" E at the altitude of approximately 750 m amsl). The climate of the region is semiarid of Mediterranean (hot and dry summer with cool and mild winter, having an annual precipitation of about 700mm). The rainfall is unimodal, falling between October and May (i.e., no rainfall over the remaining months of the year). Mean annual temperature is 19 ºC with the mean of the maximum and the minimum temperature of 45ºC (July) and of -5 ºC (January), respectively. Average annual pan evaporation is about 2000 mm. The main soil properties were determined by taking core and disturbed soil samples from the depth of 0-90 cm at three different locations in the field (Table: 2). Soil samples were air-dried and ground to pass through a 2mm sieve priorto estimate physical, chemical, and geotechnical properties using standard procedures[25].The total available water for the soil was calculated after estimating each of the soil water content at -33 and -1500 kPa from the models proposed below by [26].

$$W.P = 4.57 + 0.35(\text{clay }\%) \quad \ldots\ldots\ldots\ldots (1)$$

$$F.C = 13.28 + 0.397(\text{clay }\%) \quad \ldots\ldots\ldots\ldots (2)$$

where:

W.P = soil water content at -1500 kPa.

F.C = soil water content at -33 kPa.

A factorial experiment was laid out in the split-plot design with three replicates. The levels of irrigation factor were implemented in the main plots and conducted with Randomized Complete Block Design (RCBD), and the techniques of irrigation factor were implemented in subplots.The plots were sown with corn (Maize Hybrid F1 Furat) at a rate of 84000 plants per a hectare (i.e., distance between rows is 70cm and 17cm plant intervals)

The field was prepared for cultivation by plowing the soil with moldboard and then softened with rotivator. Nitrogen fertilization was added in the form of urea (46% N) at a rate of 200 Kg ha^{-1} by spreading application, the first half was applied after 23 days from sowing and the second half was applied at tasseling stage [27]. Phosphorous was applied at a rate of 200 Kg ha^{-1} as 48% T.S.P before planting. When the plant reached the stage of 4-5 leaf, atrazine was applied at a rate of 0.85 Kg ha^{-1}[28].

Table-2: Some physical and chemical properties of the studied soil.

Properties		*Unit*	*Soil depth **(0-90)**cm*
Sand		$g\ kg^{-1}$	*70*
Silt		$g\ kg^{-1}$	*490*
Clay		$g\ kg^{-1}$	*440*
Textural class		------	*Silty Clay*
Water content at -33 kPa		mmm^{-1}	*228*
Water content at -1500 kPa		mmm^{-1}	*148*
Maximum water holding capacity		mmm^{-1}	*80*
Bulk density		$Mg\ m^{-3}$	*1.36*
ECe at 25°C		$dS\ m^{-1}$	*0.39*
pH		------	*7.71*
CEC		$cmole_c\ kg^{-1}$	*38*
$CaCO_3$*equivalent*		$g\ kg^{-1}$	*270*
Organic matter		$g\ kg^{-1}$	*12.4*
Soluble Cations	*Calcium* Ca^{2+}	$mmole_c\ L^{-1}$	*4.4*
	Magnesium Mg^{2+}		*0.9*
	Potassium K^{+}		*0.15*
	Sodium Na^{+}		*0.44*
Soluble Anions	*Carbonate* CO_3^{2-}		*0.00*
	Bicarbonate HCO_3^{-}		*3.11*
	Chloride Cl^{-}		*1.56*
	Sulphate SO_4^{2-}		*1.22*

To study the effect of water stress and its treatments on any crop, it is important to maintain optimal agronomic conditions (tillage, fertilizing, pesticides, herbicides…etc.) in order to evaluate this effect independently from other agronomic factors that may influence crop development. Therefore, in the current experiment, considerable effort was made to ensure the existence of optimum agronomic conditions.

The first factor has two levels of irrigation I_1 (no water stress) and I_2 (water Stress) were applied to the root zone depending on soil water depletion replenishments. Symbols I_1 and I_2refer to levels receiving 100% and 65% of calculated evapotranspiration which is based on soil moisture balance method. After sowing, the plots wereirrigatedby sprinkler system at the beginning stage for uniform plant establishment. In this stage, irrigation was carried out eleven times. The levels of irrigation were applied after 24 days from the sowing and were ended at 108 days after sowing. The first irrigation amount applied which was 44 mm; cumulative depth of irrigation and precipitation from emergence stage to physiological maturity or harvesting stage was practically measured and found to be 781 and 606 mm for full and deficit irrigations, respectively(Figure: 1). While, cumulative evapotranspiration based on irrigation efficiency were calculatedand found to be (ET_m=680mm) and (ET_a=505mm) for full and deficit irrigations, respectively (Figure:2)

In the case of no water stress ($k_s = ET_a/ET_m = 1$) as shown for full irrigation treatment, and then $k_s$was calculated for deficit irrigation treatment, the average values was ($k_s = ET_a/ET_m = 0.74$) which indicates the degree of water stress. The outcome was not according to what was planned for in terms of $k_s$value, which believed to be ranged from 0.65 to 0.70. The reason of this inconsistency might refer to the unexpected amount of precipitation by that time, which is why the value of $k_s$arose from 0.65 to 0.74, although it does not mean that stress did not happen. Certainly, stress was happening on most of the stages of corn growth and yield properties.

The second treatment with three techniques of drip irrigation system was used in:

1. The drip lines were installed on the soil surface 70 cm apart with emitters at 17 cm using a drip line for each row of the corn plants and the discharge of the compensated dripper was 2 L hr^{-1} at 2.2 bar pump pressure with uniformity distribution of 96% for the system which was estimated by equation (3) according to [29].

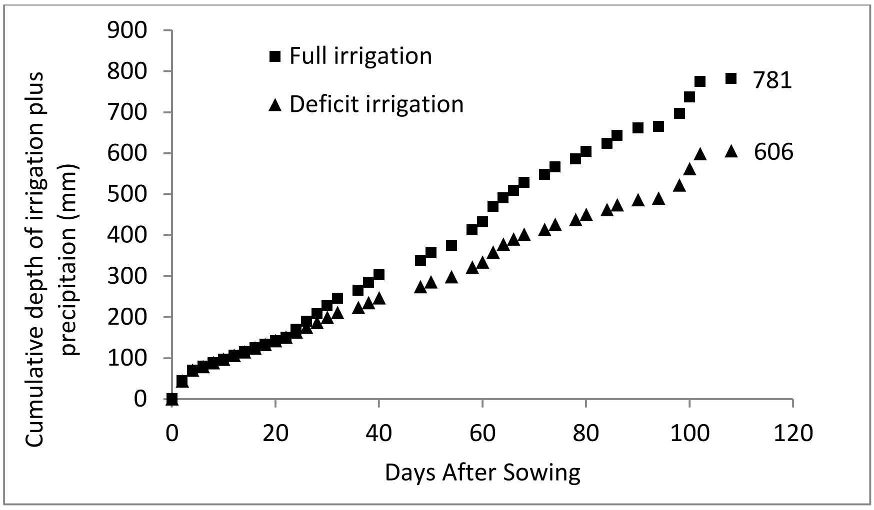


Figure-1: Cumulative depth of applied water for full and deficit treatments

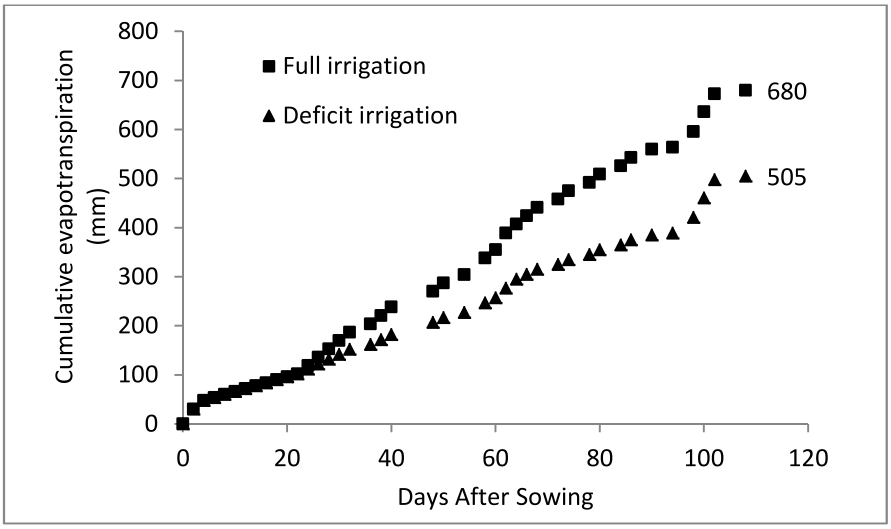


Figure-2: Cumulative evapotranspirationfor full and deficit treatments.

$$CU = \left(1 - \frac{\sum_{i=1}^{n} |q_i - q_{ave}|}{\sum_{i=1}^{n} q_i}\right) 100 \ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

where:

CU=uniformity coefficient

q_i = individual emitter flow rate, q_{ave} = mean emitter flow rate, and $|q_i - q_{ave}|$ = absolute deviation from the mean. The CU classification is ranked as >89% excellent, 80-89% good, 70-79% fair, and <70% poor.

2. The drip lines were installed at the depth of 0, 5, 15 and 30 cm from the soil surface (DI, SDI_5, SDI_{15}, and SDI_{30}). Lateral and emitter spacing has been maintained as mentioned previously.
3. The drip lines were installed on the soil surface with the same spacing for lateral and emitter with using plastic pipe under each emitter, the plastic pipes were placed vertically in predrilled holes such that tops of the plastic pipes were level with the bed soil surface, length of plastic pipes were 5, 15 and 30 cm (BT_5, BT_{15}, BT_{30}) filled by gravel (4-6 mm) in diameter (Figure: 3).

The evaluation of irrigation techniques on confronting agricultural drought was estimated by grain yield,irrigation water use efficiency, andyield response factor:

Grain yield (Y)the grain yields of corn for the different irrigation (full and deficit) treatments were collected by the end of the growing season and the moisture content was converted to 15.5%.

In this study, Irrigation water use efficiency (IWUE) was used to determine water productivity.it could be a quite useful parameter to be used because the high water efficiency arises from higher yield and lower crop water requirement. it was calculated from the following equation[30].

$IWUE= Y/I$ …………… (4)

Where:

Y: Yield (kg m^{-2})

I: total depth of water applied ($m^3\ m^{-2}$)

The yield response factor was calculated using the following equation [31].

$K_y = [1-(Y_a / Y_m)] / [1-(ET_a / ET_m)]$ …………….. (5)

Where:

K_y = yield response factor

Y_a = actual yield of the treatment exposed to deficit irrigation (kg m^{-2})

Y_m = maximum yield obtained under full irrigation (kg m^{-2})

ET_a= actual evapotranspiration for the treatment exposed to deficit irrigation (mm)

ET_m = maximum evapotranspiration (mm)

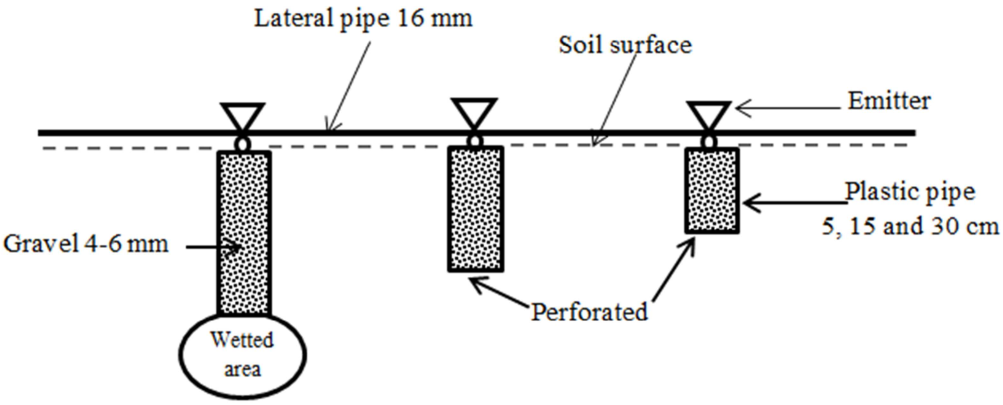


Figure-3: Drip irrigation techniques used in the study.

Results and Discussion

Grain Yield

As known, the final objective behind any crop experiment is to obtain higher product in case of the absence of water shortage. While, in this region like any other arid and semi-arid regions, the purpose will change to receive a high productivity by using low amount of water.Statistical analysis of the data showed significant difference in grain yield due to different irrigation levels (Table: 3); this result is in agreement with the findings of several researchers [10; 32; 33]. They reported that corn yield under full irrigation was significantly greater than under limited irrigation.

The highest grain yield of 12.240 Mg ha^{-1} was obtained from full irrigation as a mean of irrigation techniques, while the lowest grain yield of 8.502 Mg ha^{-1} was obtained from deficit irrigation. Average yield decreases for deficit irrigation relative to full irrigation were 30.5%. This result is in agreement with Pandey et al (2000) [34] which stated that yield reduction (22.6–26.4%) resulted in decreasing of kernel number and weight due to deficit irrigation. Grain yield is dependent on grain number per ear and grain weight and the factors influencing these two components changes its grain yield [35]. The degree of the influence of irrigation techniques on the increasing of grain yield for mean of irrigation levels follows the sequence:

$SDI_{15}>SDI_{30}>BT_5>SDI_5>BT_{15}>BT_{30}$ in comparison with *DI* treatment and their percentages of the grain yield increasing were: 18.2%, 13.7%, 12.9%, 8.2%, 8.1%and 4.5%, respectively.

As it is shown in table (3), significant difference ($p \leq 0.05$) in grain yield between SDI_{15} and all others irrigation techniques; the irrigation technique of SDI_{15} gave the highest grain yield for both full and deficit irrigations. Their mean value for the same irrigation technique was also the highest (11.442 Mg ha^{-1}) as increased with more than 2 Mg ha^{-1} compared to *DI* (Table: 3). Also, from the same table no significant difference ($p \leq 0.05$) was realized in grain yield between SDI_{30} and BT_5; accordingly, one of these irrigation techniques can be chosen, which has cost less and the installation or setup is easier, while all irrigation techniques have significant difference ($p \leq 0.05$) in comparison with *DI* treatment (Table: 3). This shows that their soil moisture evaporation was increased when the drip line is on the soil surface, in comparison with other techniques of irrigation.

Table-3: Grain yield (Mg ha^{-1}) as affected by irrigation levels, techniques and their interaction.

Irrigation Techniques	Irrigation levels		Mean
	Full Irrigation	Deficit Irrigation	
DI	11.387	7.340	9.363d
SDI_5	11.907	8.483	10.195c
SDI_{15}	**13.547**	**9.337**	11.442a
SDI_{30}	12.647	9.063	10.855b
BT_5	12.517	8.983	10.750b
BT_{15}	12.043	8.340	10.192c
BT_{30}	11.633	7.970	9.802c
Mean	12.240a	8.502b	

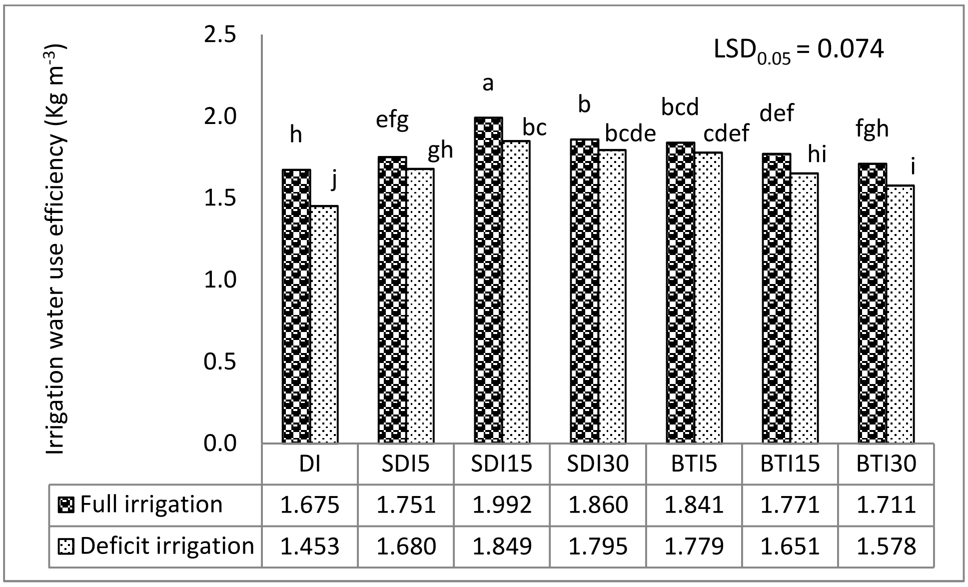
L.S.D $_{0.05}$ (Irrigation levels) = 0.424
L.S.D $_{0.05}$ (Irrigation Techniques) = 0.324
L.S.D $_{0.05}$ (Irrigation levels * Irrigation Techniques) = 0.458

Irrigation Water use efficiency (IWUE)

The farmer's goal changes to obtain maximum net income per unit water used rather than per land unit, when water supplies are limiting, by reducing irrigation water use per land unit (Deficit irrigation). It is obvious from the figure (4) that values of *IWUE* ranged from 1.675 to 1.992 kg m^{-3} for full irrigation, while for deficit irrigation it ranged between 1.453 to 1.849 kg m^{-3}. In the same figure appear that all irrigation techniques for full and deficit have significant difference ($p \leq 0.05$) in comparison with the *DI* treatment of deficit irrigation which has minimum value of *IWUE*, while the maximum value was for SDI_{15} for full irrigation. This result is in full agreement with those reported by [36; 37; 38] indicating that *IWUE* increased with the increase of irrigation depth up to the point where additional irrigation did not produce additional yield. Oktem (2008)[14] reported that *IWUE* ranged between 1.18 and 1.36 kg m^{-3} under (0, 10, 20, and 30%) deficiency of pan evaporation. Also, Aoda and Fattah (2011) [10] under the same condition of this study werefound out similar results of *IWUE* for maize which was approximately 1.2 kg m^{-3}. Also the *IWUE* values of corn were obtained by [39]as 0.96-1.43 kg m^{-3}; [32] as 1.94-2.27 kg m^{-3}; [40] as 1.04-1.36 kg m^{-3}. It was also observed from the figure (4) that the *IWUE* value of SDI_{15} gave the highest value in full and deficit irrigation. To achieve maximum water use efficiency a proper management should be implemented for irrigation system. Subsurface drip irrigation and basket technique are well methods to improve irrigation water use efficiency. Irrigation water is applied directly inside the soil instead of being on the surface [6; 41]. These techniques reduce water losses that occur due to soil water evaporation from the wet areas, as just like a soil surface that has not been wetted before, particularly for the field crops with low population density [6; 9]. Deficit irrigation also could play the same role of these techniques, which means the application of water below the ET requirements by eliminating irrigations that have little impact on yield. Therefore, water demand for irrigation can be reduced and the saved water can be used for other purposes.

In the semiarid areas in the world such as Kurdistan region of Iraq, high yields of field crops can be attained if irrigation water is applied as required. However, because of the high demand for irrigation water by the crops in these areas, the yields decrease if the water is not adequately applied both in amount and in time [19]. Thus, applying a higher degree of soil water stress (Ks), more than 0.74, is very important to optimize the use of the available water. Since water scarcity in these areas is increasing, this strategy manages the limited water to achieve the highest possible economic returns.

Values of both efficiencies were slightly different and the reason for that was related to the importance of decreasing yield slightly less than the importance of deficiency of water. Generally the percentage of *IWUE* increased for all treatments compared to surface drip. The highest increases in *IWUE* was 96.64% for SDI_5, whereas the lowest one was 86.8% for surface drip irrigation, and that the other treatments ranged between 92.25 to 96.5%, very close to the value of BT_5. The reason for having low values of *IWUE* under deficit irrigation for surface drip irrigation was related to having small plants. Hence, a few quantities of water lost by transpiration and most of the water was lost by evaporation from the soil surface, giving low population density when compared to other treatments. As it has been discussed above that might be due to the improved *IWUE* and minimized evaporative losses under subsurface, as water delivered directly to the root zone compared to surface drip irrigation method [42]. Also, Ahmed et al (2017) [43] showed that the *IWUE* for two tomato varieties under subsurface drip irrigation method is 28 % and 27 % more than that of under surface drip irrigation method, respectively.



	DI	SDI5	SDI15	SDI30	BTI5	BTI15	BTI30
▩ Full irrigation	1.675	1.751	1.992	1.860	1.841	1.771	1.711
⊡ Deficit irrigation	1.453	1.680	1.849	1.795	1.779	1.651	1.578

Figure-4: Irrigation water use efficiency as affected by different irrigation treatments.

Yield response factor (K_y)

Yield response factor to water stress was determined by applying Stewart model [31] (ratio between the relative reduction [1-[Ya/Ym)] in crop production to the relative decrease in evapotranspiration [1-(ETa/ETm)]) at any growth stage for different irrigation techniques. Statistical analysis of the data showed that all irrigation techniques differed significantly ($p \leq 0.05$) from the *DI*. By contrast, no significant differences ($p \leq 0.05$) were found among the treatments themselves (figure:5).

Yield response to water deficit is different for the different irrigation techniques; the highest value of 1.381 for the *DI* irrigation and the lowest value of 1.093 for BT_5. The yield response values obtained in this study are similar to that obtained by [44]as 1.21; by [45] as 1.29; by [14] as 1.23. On the other hand, our result was higher than the values of $K_y$obtained previously [32; 46; 47]. Abd el-wahed et al (2015) [33] reported that the rates of water saving for two seasons with apply 85 and 70% of full irrigation were 15 and 30 %, while the rates of the decrease in relative yield were 24.1 and 44.0 % in the first season, 22.8 and 41.1% in the second season, respectively, and K_y for the first season were 1.6 and 1.52 while for the second season were 1.47 and 1.37, respectively. Also, Klocke et al (2004) [46] achieved 93% of full irrigated corn yield using 76% of the water applied.

In the light of results, $K_y > 1$ in all drip irrigation techniques, it means the relative reduction in grain yield under deficit irrigation is higher than the relative reduction in evapotranspiration, in this case it is not recommendable to use deficit irrigation in semi-arid region.

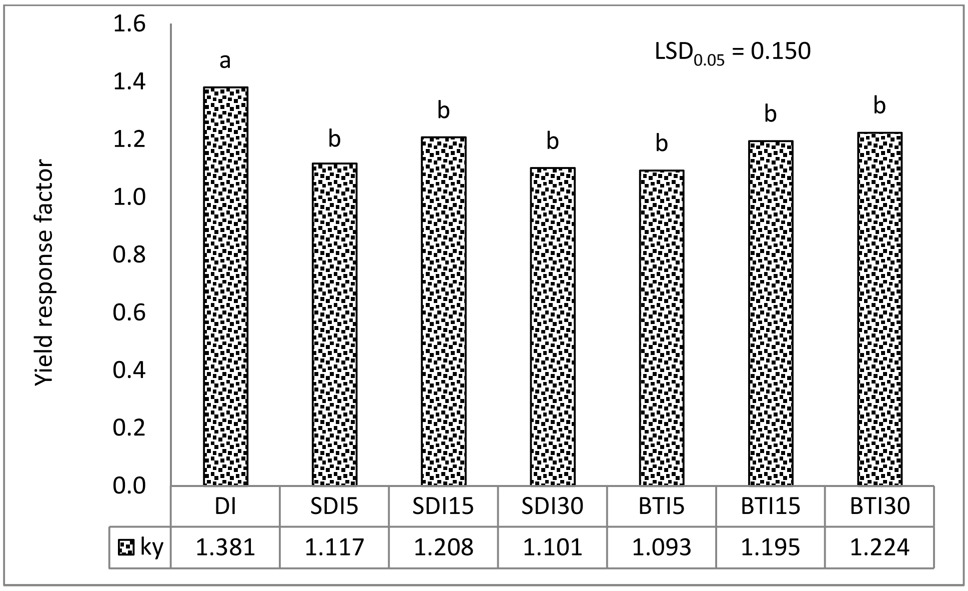


Figure-5: The yield response factor for corn under different irrigation treatments.

Conclusions

Although significant differences were observed among irrigation techniques to improve using water input, it is not preferable to apply water deficit ratio (deficit irrigation/full irrigation), smaller than 0.75 in semi-arid regions, under this condition the grain yield of corn will be more sensitive to water stress. This scenario led to the K_y for corn under all irrigation techniques larger than one, this implies that the yield loss is more important than the amount of deficit water. Based on the outcomes, it is recommendable to install the line emitters at a depth from 15cm to 30cm in silty clay texture for the purpose of confronting agricultural drought with receiving better products in respect to field crops, which is more acceptable by farmer, while installation at the depth of 5cm is recommended for *BT* if being low cost and easier setup.

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