The Effect of Different Irrigation Methods with Nano Technology on Water Consumption Rate for Yellow Corn Crop and the Water Unit Efficiency in One Plowed and One Unplowed Soil

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Abstract

A field experiment was conducted in Habbaniyah sub-district / Khalidiya district / Anbar province, western Iraq, in silty loam soil during the autumn season 2020 to study the effect of surface, subsurface drip and nanotechnology irrigation on water consumption and the efficiency of water use in plowed and non-plowed soil. Irrigation was performed upon depletion of 50% of the available water. The treatments were distributed according to the Nested-Factorial Experiments Design with three replications. Corn (Furat class) was planted, on 15/7/2020. The American evaporation basin used Class A for irrigation. The rate of water consumption was calculated in equivalent to the depth of the added water, total yield, and water use efficiency. The results showed an increase in water consumption in the surface drip irrigation which reached 748.75 and 604.80 mm. plant⁻¹ in plowing and no cultivation, respectively, while significant decrease in perfusion irrigation to 521.50 mm. plant⁻¹ in both of plowing and no tillage. The total yield exceeded in sprinkling irrigation, which reached 10.91 and 12.49 tons. hectare⁻¹, while the values of the same characteristic decreased to 7.96 and 7.11 tons. hectare⁻¹ in surface drip irrigation of the plowed and non-plowed soils, respectively. Also, the values of water use efficiency in perfusion irrigation were exceeded, and they were 2.09 and 2.39 kg.m⁻³, while the lowest values were 1.06 and 1.17 kg.m⁻³ in surface drip irrigation in plowing and no-till, respectively.

1. Introduction

The fresh water resources are a major factor of agricultural production and improvement, especially in dry and semi-dry areas that Iraq is one of them. Also the lack of agriculture water in a main problem to provide food security requirements in face with population increase when surveyed. So, there's a need to create new methods and techniques in the irrigation field to fill the gap between the available fresh water and food security; therefore, the use of available water has become a real goal that should be focused on to exploit a largest area of dry and semi-dry lands in developing reliable agriculture. The importance of studying water consumption in Iraq appears because it lies within dry and semi-dry areas; so, the importance of irrigation increases by the insufficient waterfalls under the dry and semi-dry areas conditions plus the water deficiency. So, there's a negative affection on water resources required to meet crop needs. As a result, there's an urgent need to exploit waters actively and efficiently as much as possible and that the assignment of different crops water need is the first essential step to manage ideal distribution for the available waters. The providing of few fresh waters has urged scholars to work finding out methods and techniques in the irrigation field.

Water consumption is defined as the total quantity of consume waters by a plant system (quantity of water lost from soil surface by evaporation and the quantity lost from shoot part by transpiration, and the quantity of water used to build a plant tissues). We can say that water consumption is equivalent to what so-called evapotranspiration ET when the available water in a plant at season end doesn’t exceed 1% of evapotranspiration total along with season. Water consumption could be estimated by direct and indirect ways [1]. The use and investment of new lands in agriculture requires to identify the real crops water need. Al-Kawaz and others, 1983 have found that the production of 8000 kg/hectare of yellow corn grains has required 900 ml water consumption when the water use efficiency 1.12 kg.m⁻³ grains for density 53000 plants.hec⁻¹. While Shehata (2009) has found that the highest efficiency to consume water in yellow corn was 2.44 kg.m⁻³ in the application of adding 100% of (ETp), followed by 1.77 kg.m⁻³ in the application of adding 80% of ETp and the least value for water use efficiency was 0.97 kg grains m⁻³ water in the application to add 60% of it in streaming irrigative systems, superficial and
sub-superficial successively. Also [2], referred that the irrigative method has a role in this efficiency where the efficiency in case of exudative irrigation 35.10 kg.m\(^{-3}\) compared with 28.41 kg.m\(^{-3}\) in case of distilled irrigation.

This study was made to:

a. Determine the water consumption of yellow corn plant under the study conditions.

b. Determine the irrigative methods effect and managing them on yellow corn crop and water use efficiency.

2. Materials and Procedures

A field experiment was done during Autumn 2020 in Abu Fleis District – Al Habbaniya Town – Al Anbar University West Iraq and the field soil has been morphologically classified as a colloidal mix within the group Typic Torrifluvent, Fine loamy mixed, Calcareous, hyperthermic according to [3]. Samples of field soil were taken from different places randomly at depths 0 – 0.30m and complied to some physical and chemical analyses in table (1) according to standard methods mentioned in [4].

The properties of the irrigation water were estimated according to the methods proposed by the American Salinity Laboratory, The water of the Euphrates River was used to irrigate maize crop, whose chemical properties are shown in table (2).

Table 1. Some physical and chemical characteristics of the soil before planting.

| Units      | Quantity | Adjective | Se | Units      | Quantity | Adjective | Se |
|------------|----------|-----------|----|------------|----------|-----------|----|
| ds. m\(^{-3}\) |    | pH    | 10 | g. Kg\(^{-1}\) | 222 | Sand    | 1  |
|            | 7.50     | EC      | 11 | 5.41     | 237     | Clay     | 3  |
|            | 1.25     |         |   |          |         |          |    |
| mmol. L\(^{-1}\) | 5.00   | Ca\(^{2+}\) | 4.25 | Mg\(^{2+}\) | 1.10 | Na\(^{+}\) | 0.32 |
|            | 4.25     |         |   | Cationic dissolved Ions | 12 | K\(^{+}\) | 1.5 |
|            | 1.5      |         |   | meq. m\(^{-3}\) | 1.29 | Bulk density | 6  |
|            | 1.15     |         |   | cm. hr\(^{-1}\) | 9.28 | Saturated aqueous conductivity | 3  |
|            | 0.32     |         |   |          |         |          |    |
| mmol. L\(^{-1}\) | 2.50 | HCO\(_3\) | 1.87 | CO\(_3\)\(^{2-}\) | 147.00 | (CaSO\(_4\)) Gypsum | 6  |
|            | 6.50     | Cl\(^{-}\) | 7.4 | Na\(^{+}\) | 2.10 | (CaCO\(_3\)) Lime | 9  |

The experiment included observing the effect of three different irrigation systems with nano-distillers which included superficial, sub-superficial and nano-oozing irrigation system. Then the timing of irrigation using the American Evaporating Basin class A as a primary indicator for superficial, sub superficial irrigation systems and the irrigation will be done after finishing 50% of water available to the plant and measuring it indeed with field gravity method. Also, the irrigative waters have been added to nano-oozing irrigative systems as a continuous oozing along with the season with regard to the increase and decrease of added quantity on growth stage basis and depending on water consumption rate of yellow corn plant for autumn season. In each system, it’s put the two plow methods: zero plow and traditional plow. A spot of land with 52.2m length and 21.5m width has been chosen and divided into three equal locations of dimensions 14.5m X 17.5m and separated with 2.5m space between location as guard area. Each one of the three main irrigative methods in a place vertical with dominant wind stream direction to form the main panels. Also, every irrigative system has included three replications and both blow applications were put in each replication and included a trench plow with 1.5m height and 1.5m length by the moldboard plow machine and the soil softened. A space of 1.5m has been left far from the plow application, and the unplowed application was put (as a spare to avoid interference and to smooth the plow motion when plowing the studied application and not disturbing the unplowed application). Three distilling lines were extended in each experimental unit with separating space 0.5m, thus, we have six experimental units in every irrigation system as 18 experimental units per experiment. A couple of meters were left in the experiment boarders to separate it from guard panels and cultured in both

Table 2. chemical properties of irrigation water.

| Class | SAR | NO\(_3\)\(^{+}\) | Ppm | CO\(_3\)\(^{2-}\) | HCO\(_3\) | SO\(_4\)\(^{2-}\) | Cl | K\(^{+}\) | Na\(^{+}\) | Mg\(^{2+}\) | Ca\(^{2+}\) | pH | EC | dS.m\(^{-1}\) |
|-------|-----|---------------|-----|----------------|---------|----------------|----|---------|---------|---------|---------|----|----|----------|
| Cl-S\(_1\) | 1.15 | 2.10 | 0.0 | 2.0 | 3.5 | 4.0 | 0.14 | 2.89 | 4.1 | 7.4 | 0.98 |    |    |          |
experiment sides (from the wind streaming side) to ensure reducing winds damage and providing homogenous circumstances for every application. Figure 1 states the field chart of irrigation system on which the study applications are distributed. The yellow corn seeds were cultured for autumn season Class Furat on July 15, 2020 adding 3 – 4 seeds in every hole. Only a single plant was left per a hole after two weeks of agriculture. The space between a line and another was 0.5m and between two holes 0.25m as 85 plants per agriculture line to make the plant number each system 1044 plants and for the whole experiment 3132 plants.

Nitrogen was added from urea fertilizer as 400 kg/hectare in two loads: the first one included 200 kg/hectare with 260 kg/hectare of super triphosphate before agriculture, while the second load was added five weeks after agriculture. The crop management process like periodic grass erase was made for all the treatments, while the stem digger pest Sesamia Cretica L. was eradicated with pesticide (grainy diaxenon 10% active material) as 6 kg/hectare inserted in plant medulla in 20 days after the date of agriculture thrice with time space 10 days. The actual water consumption (ETa) that equals the added water depth (d) and irrigative timing has been calculated depending on the actually exhausted moisture in the field using the gravity method and depending on basin data as a primary indicator, as follows:

\[ d = \frac{\theta f.c - \theta wi}{100} \times D \quad (1) \]

Whereas:

\( d \) = depth of water that must be added to soil (cm), that equals the actual water consumption (ETa).

\( D \) = active radical group depth.

Evaporation-reverse transpiration (ETo) has been determined according to equation mentioned in [5], like the following:

\[ ETo = \frac{ETa}{Kc} \quad (2) \]

Whereas:

\( ETo \) : Evaporation-reverse transpiration mm.day\(^{-1}\) and \( ETa \) : Evaporation-actual transpiration mm.day\(^{-1}\)

\( Kc \) : theoretic crop factorial depended for different growth stages (0.94 ,1.05 ,1.69 and 0.82) for germination, vegetative growth, flowering and maturation successively. Mentioned in [6].

The \( E_{pan} \) value that equals the basin evaporation percentage has been found according to the equation mentioned in (Al-Hadithi at el, 2010) as follows:

\[ E_{pan} = \frac{ETo}{Kp} \quad (3) \]

Where:

\( E_{pan} \) = water depth (mm) required to evaporate from evaporation basin which informs us about actual soil moisture.

\( Kp \) = evaporation basin factorial which differs by basin type, ambient plant cover and soil surface nature [7]. The value 0.8 in this study was depended on the basis of what’s mentioned in. The water added to soil as salt wash requirements for 6.25% salts of added water depth was determined according to the equation that [8], suggested for modern irrigation systems like irrigative distillation as the following:

\[ LR = \frac{Ec iw}{2(max Ec e)} \quad (4) \]

LR: wash requirements Ec iw: irrigation water salinity. Decisiemens.m\(^{-1}\).

max Ec e: maximum salt percentage Decisiemens.m\(^{-1}\) for farm soil at which the crop total equals zero. This value differs by crop type. It equals (10) for yellow corn crop [9].
Figure 1. Field diagram and irrigation system.

It's been calculated the total crop after the harvest on October 25, 2020.

The crop water use efficiency was calculated according to the following equation [10]:

\[
\text{WUE} = \frac{\text{Yield}}{\text{Irrigation Water applied}}
\]  

(5)

Where:
- WUE: water use efficiency (kg. m\(^{-3}\))
- Yield: total crop (kg. hec\(^{-1}\))

Results have been analyzed by Genstat v.12.1 program and averages have been compared by the least significant difference (LSD) at probability level (0.05).

3. Results and Discussion

3.1. Water Consumption Rate (mm)

Table (3) shows the irrigation method effect on the average water consumption of yellow corn plant during the growth season. It has decreased in oozing irrigation and increased in superficial distillation for both plow patterns that reached 521.5 mm.plant\(^{-1}\) in oozing irrigation for plowed and unplowed soil; but reached 748.75 and 604.8 mm.plant\(^{-1}\) under superficial oozing irrigation system for plowed and unplowed soil successively. It could be attributed to the dogma of oozing irrigation where it adds water directly to the root under the water surface where there's no evaporation from soil to air, in addition to control the by-stream just like in superficial irrigation, it agrees with what has found in [2].
It is noticed from table 3 that oozing irrigation led to save a quantity of irrigation water about 833 m$^3$ in comparison with applying superficial distillation for irrigation in unplowed soil, with increase percentage 15.97%. these waters could be exploited in extra areas about 0.1587 hectares and this is equivalent to total productivity that could access 1.53, 1.73 and 1.99 ton.hec$^{-1}$ if these waters were applied with oozing irrigation for unplowed soil. As well that interference amongst the study factors has saved about 43.57% added waters as 2272.49 m$^3$ to irrigated area about 0.4357 hectares and this percentage could achieve 5.44 tons.hec$^{-1}$ production when applied by oozing irrigation to unplowed soil when compared with irrigation by superficial distillation for plowed soil with complete, half and triple addition successively. The survey analysis results have confirmed the significance of this productivity.

### Table 3. The total depth and volume of water added during the growth season.

| Irrigation system       | Volume of irrigation (m$^3$. h$^{-1}$) | Number of irrigation | Irrigation efficiency % | Depth of the req. of leaching (mm. season$^{-1}$) | Depth of water added actually | Tillage | Irrigation |
|-------------------------|--------------------------------------|----------------------|-------------------------|--------------------------------------------------|--------------------------------|---------|------------|
| Surface drip irrigation | 7487.5                               | 26                   | 85                      | 46.805                                           | 748.75                         | T       | Surface drip irrigation |
| Subsurface drip irrigation | 6048                                 | 24                   | 83                      | 37.812                                           | 604.8                          | NT      | Subsurface drip irrigation |
| Drain irrigation system | 5669                                 | 20                   | 96                      | 35.439                                           | 566.9                          | NT      | Drain irrigation system |
| Drain irrigation system | 5215                                 | —                    | 100                     | 32.594                                           | 521.500                        | T       | Drain irrigation system |
| Drain irrigation system | 5215                                 | —                    | 100                     | 32.594                                           | 521.500                        | NT      | Drain irrigation system |

### 3.2. Total Yield (ton.hec$^{-1}$)

Table 4 refers to the irrigation methods effect on total yield of yellow corn grains. It's significantly increased at oozing irrigation to reach average 11.7 ton.hec$^{-1}$ with percentage of increase 55.37 and 35.70% compared with both superficial and sub superficial methods for the two plow patterns successively. It is due to continuous water addition according to plant need (without irrigation space) in case of oozing irrigation and increase of soil water content at radical area to lighten osmotic pressure that helps the seeds growth and spread to increase, and thus increasing plant activity and faster growth which reflect positively on yield increase as well as keeping continuous dissolve of nutrients in soil, [2].

The same table refers to the effect of two plow patterns on average yellow corn yield. It reached a highest production 9.6 ton.hec$^{-1}$ in unplowed soil with percentage 7.14% increase in comparison with plowed soil for every irrigation system. This increase could be a result not to plow the soil and keeping its texture, so the soil keeps water longer when compared with plowed soil that loses more water with evaporation and deep infiltration for its wider pores [7].

### Table 4. The effect of study coefficients on total yield (tons. h$^{-1}$).

| Irrigation Average | The pattern of tillage | Irrigation systems |
|--------------------|------------------------|--------------------|
| 7.530              | 7.110                  | Surface drip irrigation |
| 8.620              | 8.020                  | Subsurface drip irrigation |
| 11.700             | 10.910                 | Drain irrigation system |
| 1.955              | N.S                    | Average tillage |
| 9.600              | 8.960                  | LSD                |

### 3.3. Water Use Efficiency (kg.m$^{-3}$)

Table 5 illustrates the study factorials effect in water use efficiency values calculated by equation 5. It is obvious the superiority of water use efficiency significantly when oozing irrigated to reach 2.09 kg.m$^{-3}$ with average increase percentage 44.13% compared with sub superficial distil irrigation, while it was 86.6% in comparison with superficial distil irrigation.
method in plowed and unplowed soils. The reason is the ooze irrigation efficiency in saving the added waters (table 3) to reduce the oozed water of irrigation because of sub superficial support of water continuous away of evaporation. In addition to several spotted cases during the experiment time that are the increase and decrease of oozed waters automatically on the basis of circumstances that a plant undergoes. It takes a least quantity of water when temperature decreases especially in the night, while it takes the biggest in daytime when temperature increases. It makes the soil moisture within the optimum limits for a plant to achieve positive reflection on its health status and increase of productivity, [2].

Also the results of the same table indicate an increase in average water use efficiency significantly in unplowed water that was 1.63 kg.m$^{-3}$ with increase percentage 10.13% compared with plowed soil for the three irrigation methods. It is because of enhanced unplowed soil texture and keeping suitable level of moisture; so, the irrigations number has decreased in unplowed soil in both superficial and sub superficial distil irrigation cases. In other hand, it's because of grains yield due to successful inoculation and fertilization due to the continuity of suitable moisture in case of oozing irrigation, [7].

Table 5. The effect of study coefficients on water use efficiency (Kg. m$^{-3}$).

| Irrigation Average | The pattern of tillage | Irrigation systems |
|--------------------|------------------------|--------------------|
| 1.120              | 1.177                  | NT                 |
| 1.458              | 1.624                  | T                  |
| 2.240              | 2.390                  | Surface drip irrigation |
| 0.009              | 0.009                  | Subsurface drip irrigation |
| 1.730              | 1.482                  | Drain irrigation system |
| 0.004              |                        | Average tillage    |

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