The Effect of some Irrigation Methods and Moisture Depletion percent in the Growth and Productivity of Corn

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DOI: https://doi.org/10.36077/kjas/2023/v15i1.3703

Received date19/6/2022

Accepted date13/7/2022

Abstract

The experiment was conducted in the fields of Al-Hilla - Babylon province, with loam soil, during the autumn season of 2021, to study the effect of different irrigation methods and levels of depletions on the growth and yield of corn (*Zea mays* L.). The Randomized Complete Block Design (RCBD) was an as complete split plot with three replications, the main plot included the treatment of depletion levels and subplot irrigation systems, and the treatments were distributed on the experimental plots randomly. Irrigation systems included three levels of subsurface drip irrigation - surface drip irrigation - surface irrigation with furrows, and the levels of depletion for each treatment were 20%, 40%, and 60%. The result showed that the subsurface drip irrigation treatment with 40% depletion achieved the highest plant height (206.92). While there was no significant difference with the surface drip treatment. The furrows irrigation system has the lowest plant height, which reached (174.14). There are significant differences between the treatment and the level of depletion in the area of the leaves of the plant. Also, the irrigation methods used did not significantly affect the weight and depth of the roots, while there were significant differences in the values of yield weight for the treatments and water depletion rates.

Keywords: Moisture depletion percent. Drip irrigation. Yellow corn.

Introduction

Micro irrigation systems or less flow irrigation systems such as Surface drip irrigation (DI) and Subsurface drip irrigation (SDI) are water efficient, Where the water requirements of plants are few with few water additions and high frequency, and the initial costs of preparing the land and cultivating are almost non-existent and a clear saving in the use of fertilizers. Both DI and SDI are two distinct methods of effective irrigation in achieving the water requirements of plants and at the same time working to save water and reduce waste and water losses. Precision irrigation systems require good management and accumulated experience to control more than one common factor affecting the homogeneity of irrigation water distribution, such as drip lines, the distance between them, depth of drip line position, the distance between emitters, operational pressure, emitters discharge rate, irrigation frequency and irrigation time (5). The drip irrigation system is a globally approved system for its high irrigation efficiency and efficiency of use. It is an effective method for rationing water and fertilizers. It facilitates the addition of chemical fertilizers in the form of a solution mixed with irrigation water and pumped directly into the area of the spread of the root group. Thus, the possibility of holding and inhibiting fertilizers in the soil was excelled, as well as the high efficiency in transferring the distribution of Water using pipes without the need to make furrows or conveying channels. The plant needs water during the stages of growth in order to be productive so that it is not exposed to water stress in the soil, and corn is one of the economically important grain crops and occupies the third place in the strategy after wheat and rice. It enters into human and animal nutrition and is characterized by its high production of dry crops. Therefore, it needs high amounts of water as a result of high rates of evaporation during its growth period in (July, August, and September) the months with the highest temperatures. Irrigation scheduling must be adopted, which aims to give the plant an optimum amount of water to increase the yield, with the possibility of keeping the soil moisture content close to the moisture content of the field capacity. The study aims to: Study the performance of subsurface irrigation under the conditions of levels of moisture depletion from the field capacity (20, 40%, and 60%) and its effects on each of the growth indicators and yield the d of corn crop, water use efficiency- which expresses the extent of plant utilization with added water.

Materials and Methods

A field experiment was conducted in the fields of the Al-Wardiya area, Al-Hilla district, belonging to Babylon province, during the fall season of 2021, located at a latitude of letter N 24.178” 32º 28’ North, longitude 56.459’ 36’ 44º east, at a height of 31 m above the level of sea level. The study area is characterized by a flat to semi-flat topography with a slope of less than 2%. The soil of the field was classified as sedimentary with a mixed texture of Silt loam, which is classified under the Typic torrifluvent group according to classification (10) before cultivation, soil samples were taken randomly from several locations in the field, and the dimensions of which are 35 in length and 13 in width and at two depths of 0.00 - 020 m, The samples were dried, and passed through a sieve with an aperture of 2 mm. The samples were well mixed together, and a single compound sample was taken, which was used to estimate some physical and chemical properties of the soil

Table (1) some physical traits of field soil before cultivation

Traits	soil depth 0 – 0.20
sand (gm kg^{-1})	264
Silt (gmkg^{-1})	397
Clay (gmkg^{-1})	339
soil texture	Clay loam
Bulk density (Mg. m^{-3})	1.33
true density (Mg. m^{-3})	2.65
Total Porosity (%)	49.8
Volumetric moisture content at 33 kPa (cm^3 cm^{-3})	0.32
Volumetric moisture content at 1500 kPa ($cm^3 cm^{-3}$)	0.13
available water ($cm^3 cm^{-3}$)	0.19
Saturated Hydraulic Conductivity ($cm.h^{-1}$)	3.20

Table (2) some chemical traits of field soil before cultivation

Traits	Units	soil depth(m) 0.00 – 0.20
Soil salinity Ece	$ds.m^{-1}$	1.56
Ph	-	7.4
Organic matter	%	0.31
Calcium		2.7
Magnesium		2.62
Sodium		5.9
Potassium	mmol L^{-1}	0.71
Sulfate		2.3
chloride		4.5
Carbonate		
bicarbonate		1.8
available phosphorus	$Mg.kg^{-1}$	6.93
total nitrogen	%	1.7
CEC	Cmol c Kg^{-1}	15.83
Sodium adsorption ratio (SAR)	mmol L^{-1}	2.55

The water used in the experiment was analyzed for irrigation. The water category, which was C1 S3, was determined according to the Irrigation Water Use Guide (8) and as shown in Table (3).

Table (3) Chemical analysis of irrigation water

Traits	Values
Electrical conductivity EC ($dS.m^{-1}$)	0.78
Ph	7.56
Calcium Ca^{+2} (mmol L^{-1})	3.56
Magnesium Mg^{+2} (mmol L^{-1})	3.17
Sodium Na^{+} (mmol L^{-1})	2.81
Potassium K^{+} (mmol L^{-1})	0.12
Chloride Cl^{-} (mmol L^{-1})	2.09
Sulfate $SO4^{-2}$ (mmol L^{-1})	4.56
Carbonate Co_3^{-2}	4.7
HCO_3^{-1} Bicarbonate (mmol L^{-1})	2.21
Nitrate NO_3^{-1} (mmol L^{-1})	0.09
Sodium adsorption ratio SAR mmol L^{-1}	1.08
water class	C_1S_3

Experiment treatments and statistical design

The experiment was designed according to the design of complete sectors RCBD according to the arrangement of the strip-split-plot plates with three replications. The data of the experiment were statistically analyzed using the (GenStat) program, and the least significant difference at the 0.05 level was selected to compare the arithmetic means of the transactions Table (4) shows the symbols of the experiment's coefficients, and the transactions included the following:

First: Irrigation systems at three levels:

1. Sub-surface Drip Irrigation (SDI), which is symbolized by (I_1)

2. Surface Drip Irrigation (DI) which is symbolized by (I_2)

3. Irrigation (SI) which is symbolized by (I_3)'

Table (4) Experiment treatments symbols

No.	Symbol	depletion levels
1	I_1M_1	Subsurface drip irrigation with a depletion level of 20%
2	I_1M_2	Subsurface drip irrigation with a depletion level of 40%.
3	I_1M_3	Subsurface drip irrigation with a depletion level of 60%.
4	I_2M_1	Surface drip irrigation with a depletion level of 20%
5	I_2M_2	Surface drip irrigation with a depletion level of 40%
6	I_1M_3	Surface drip irrigation with a depletion level of 60%
7	I_2M_3	Furrow irrigation with a depletion level of 20%
8	I_3M_1	Furrow irrigation with a depletion level of 40%
9	I_3M_2	Furrow irrigation a depletion level of 60%

Planting

Seeds of yellow corn (*Zea mays* L.) Al-Furat hybrid cultivar from the Dutch company Monarch, planted on 07/22/2021 the planting was conducted in the form of roses within experimental units facing east to west, and each unit included 3 rows. The distance between one lane and another is 0.75 m, and between one line and another is 0.30 m, with 7 pits for each lane and a total of 21 pits for each plot of the experimental treatments. The plants were harvested on 20/11/2120. (The growing season is 120 days).

Fertilization

The addition of fertilizers was conducted according to the recommendation of corn fertilizer, and it included 200 kg of nitrogen, 78.5 kg of phosphorous, 120 kg of potassium ha^{-1} (1), and the use of DAP fertilizer (18%N and 23.3%P) and K-potassium sulfate (41.5%). DAP fertilizer and potassium sulfate were added when preparing the land at the beginning of the cultivation process, while urea (46% N) was added in two batches.

Measurement of growth and yield components of corn plant parameters

1. Plant height

Upon completion of the flowering stage, seven plants were randomly taken from the guarded plants from each line, seven plants, whose heights were measured, according to the rate of plant height from the surface of the earth to the lower node of the male inflorescence (3 and 9).

2. Leaf area and Leaf area index

The average total leaf area of the plant (cm^2) was calculated by multiplying the square of the length of the leaf under the main cob leaf by 0.75 (11).

As for the leaf area index only for each plant, through the following equation.

$$LAI = \frac{LA}{A} \quad (5)$$

LAI: leaf area index.

A: The area occupied by the plant from the ground (0.75 x 0.20 meters).

LA = average total leaf area of a plant (cm^2).

1. Vegetative dry weight of the plant

Plants of each experimental unit (21 plants) were harvested, cut, and packed into a bag, and then left to air dry until the weight stabilized, and then transferred to the oven at a temperature of 65 °C, and then according to the weight in units of $g.plant^{-1}$.

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

The cob was harvested for each treatment at the full maturity stage of the corn crop, then they were harvested manually, and the grains were weighed after air-drying. Then the average of one plant was calculated and the result was extracted by multiplying the average yield of the plant by the density of the plant used. The weight was adjusted based on the humidity of 15.5%, and the total production was estimated according to what was mentioned in Al-Khafaf *et al*. (2).

3. Root dry weight and length

After the full maturity of the maize crop has been completed and the stems have been cut from the area that contacts the surface of the soil (the area where the stem contacts the roots), which are 21 plants. The roots were extracted by making a hole 0.25 m wide on both sides of the stem and 0.70 m deep from the root zone so that we could raise the soil with the roots of the plant. Then the roots were separated from the soil by the method suggested by Howell(7), after which the roots were dried in an oven at a temperature of 65 °C for 48 hours, then the dry weight of the roots and their lengths were calculated.

Irrigation water productivity

1. Field water use Efficiency WUEf

The efficiency of field water use was calculated according to the following equation (6).

$$WUE_f = \frac{Yield}{Water\ applied} \qquad (10)$$

2. Crop water use efficiency WUEc.

The efficiency of crop water use was calculated according to the following equation (6)

$$WUE_c = \frac{Yield}{ET_a} \quad (8)$$

3. Water storage efficiency

The water storage in the soil was calculated using the following equation (6).

$$Es = \left[\frac{Ws}{Wn}\right] \times 100 \ \ (1)$$

Results and Discussion

Plant parameters (growth and yield)

1. Plant height

The results in Table (5), showed that there is the effect of irrigation systems treatments and levels of depletion on the height of corn, where the plant height reached 197.87, 206.92, 205.13, 183.77, 199.20, 191.03, 17127, 177.97, and 173.20. I1M2, I1M3, I2M1, I2M2, I2M3, I3M1, I3M2, I3M3, respectively. Irrigation treatments affected the average plant height, as the I1M2 sub-surface drip irrigation treatment gave the highest average plant height of 203.31, followed by the surface dripping treatment, which did not significantly differ with it, and the average plant height was 191.33 cm. The reason for the excelled of the average plant height in the two subsurface drip irrigation systems can be due to the homogeneity of the moisture distribution in the root zone as well as the provision of irrigation water by creating a good moisture balance at the appropriate depth in the root zone in addition to the fact that the subsurface irrigation system works on the lack of adequate moisture in the root zone, which negatively affects the absorption of nutrients, including NPK, and its movement from the soil to the plant. This affects the overall morphological traits, including plant height. Also, the lack of soil moisture in the root zone causes a decrease in the water content of the cell, which determines the elongation of the stem. There was a decrease in the plant height compared to the subsurface drip and surface drip irrigation treatments, and the average plant height decreased by 14.34 and 8.98% in the I3 drip irrigation treatment compared to the subsurface drip irrigation I1 and the conventional I3 irrigation respectively.

Table (5). Effect of irrigation systems and depletion levels on plant height (cm)

I	M1	M2	M3	Average
I1	197.87	206.92	205.13	203.31
I2	183.77	199.20	191.03	191.33
I3	171.27	177.97	173.20	174.14
LSDI 2.620			N.S	
Average	184.30 LSDM 2.620	194.69	189.79	

2. Leaf area

The results in Table (6) the effect of the coefficients of depletion levels and irrigation systems on the values of the leaf area for yellow corn. The results of the statistical analysis showed that there were no significant differences in the values of leaf area for the triple interaction. The values of the leaf area of yellow corn ranged between 3807.3 and 5051.7 cm^2 $plant^{-1}$. It was found that the average leaf area increased when the subsurface drip irrigation I1 was treated, reaching 5040.6 compared to the treatment of I2 and I3, with a rising rate of 3.50 and 30.33%, respectively. This difference in the leaf area of the yellow corn for the studied treatments can be due to the effect of the different stages of plant growth on the availability of water, and thus all physiological processes of the plant will be affected by the moisture content, the amount and time of adding water, and then the leaf area will be affected. This may be due to a deficiency in the formation of amino acids, which reduces the rate of protein formation from these acids, as well as reducing photosynthesis and increasing hydrolysis as a result of changing these physiological processes in the plant, which is reflected in the average leaf area. This is consistent with what was found Wu *et al*. (13).

Table (6): Effect of depletion level treatments and irrigation systems on the leaf area of the corn plant

I	M1	M2	M3	Average
I1	5024.9	5051.7	5045.2	5040.6
I2	4807.5	4955.6	4846.2	4869.8
I3	3807.3	3953	3841.9	3867.4
LSDI 32.5			N.S	
Average	4546.6 LSDM 32.5	4653.5	4577.8	

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

Table (7) shows the effect of the treatments of depletion levels and irrigation systems used on the dry weight of corn grains. The highest grain yield was 11.87 Mg.ha-1 for I1M2 treatment and the lowest value for I3M1 was 8,443 $Mg.ha^{-1}$.The results of the statistical analysis showed that there were significant differences in the weight of dry grain for the treatments implemented in the experiment, as well as the interaction between them. It was found that the irrigation systems treatments had a significant effect on the dry weight of the grains, and the reason for this was due to the amount of water applied, the date of addition, and the quantities of water consumption, which differed according to the different irrigation methods, as well as the difference in the moisture distribution pattern in the effective root zone according to the irrigation methods. This affected the grain yield because plant growth is the result of all physiological processes such as photosynthesis, respiration, nutrient absorption, food transfer within the plant, and other processes. These are all affected by the moisture distribution of the soil and the availability of moisture throughout the growth period at the limits of the field capacity. These results were in agreement with what was found Rosa *et al*. (12).

Table (7): Effect of depletion levels and irrigation systems on yield weight ($Mg.ha^{-1}$.).

I	M1	M2	M3	Average
I1	10.513	11.87	11.23	11.204
I2	9.693	10.260	9.840	9.931
I3	8.443	8.737	8.693	8.624
LSDI 0.2954			N.S	
Average	9.550 LSDM 0.2954	10.289	9.921	

4. Dry vegetative weight ($Mg.ha^{-1}$)

The results in Table (8) show an insignificant effect of irrigation systems on the dry weight of corn. The highest value was recorded for the I1M2 treatment, which amounted to 11.317, while the lowest value was 9.023 for the I3M1 treatment. This difference between the results of the studied characteristic comes as a result of the difference in the irrigation method and the moisture contents used, which were represented by the studied treatments. This can be explained that the irrigation method and the used moisture levels helped to provide adequate moisture storage in the soil. Which helped the plant to obtain its 100 needs, complete its vital activities, growth, and development, as well as maintain the thermal regime of the soil, which reduced the amount of evaporation from the soil surface, and thus helped the plant to take advantage of the moisture and build its tissues in a better method. This was in line with what was found by Banik *et al*. (4).

Table (8) Effect of depletion levels and irrigation systems on vegetative dry weight ($Mg.ha^{-1}$)

I	M1	M2	M3	Average
I1	10.383	11.317	10.620	10.773
I2	9.787	10.277	10.110	10.058
I3	9.023	9.833	9.663	9.507
LSDI 0.2152			n.s	
Average	9.731	10.476	10.131	
	LSDM 0.2152			

5. Root weight and depth

It is clear from the results in tables (9and 10) the effect of irrigation systems and different levels of depletion on the weight and depth of the dry roots of corn plants, as the two treatments I3M1 and I2M1 shared the lowest value of root weight and amounted to 40.30, 42.33 $g.plant^{-1}$, respectively, while the treatment I1M2 had the highest The value of root weight was 50.70 $g.plant^{-1}$. The results of the statistical analysis showed that there were no significant differences in the weight and depth of the roots of the irrigation systems treatments implemented in the experiment, as well as the interaction between them. The two tables show the effect of moral irrigation system treatments on the average root weight and depth of corn plants, as I1 had the highest mean root weight and depth of 49.83 $g.plant^{-1}$.The reason for the excelled of the I1M2 treatment in increasing the dry weight and the depth of the rootstock can be due to its role in improving the physical, chemical, and biological properties of the soil and increasing the microbial activity in the soil, which led to the presence of a good structure, good ventilation and the availability of appropriate moisture. These all led to the development of the roots of yellow corn then its weight increased and its depth in the soil and these results may be in line with what was obtained Wu *et al.* (13)

Table (9): The effect of depletion levels and irrigation systems on dry root weight ($g.plant^{-1}$)

I	M1	M2	M3	Average
I1	48.90	50.70	49.90	49.83
I2	42.33	45.70	43.67	43.90
I3	40.30	44.93	41.43	42.22
LSDI 0.621			n.s	
Average	43.84	47.11	45.00	
	LSDM 0.621			

Table (10): The effect of depletion levels and irrigation systems on root depth (mm)

I	M1	M2	M3	Average
I1	52.67	54.60	54.23	53.83
I2	41.77	43.27	42.63	42.56
I3	39.27	40.37	39.57	39.73
LSDI 0.4213			n.s	
Average	44.57 LSDM 0.4213	46.08	45.48	

Conflict of interest

The authors have no conflict of interest.

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