Effect of Irrigation Methods and Moisture Depletion on Some Growth Characteristics and Yield of Maize

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Abstract

An experiment was carried out in the fall of 2022 in a field in the Qasim District of Babylon Governorate, which is known for its silty clay loam soil, to examine the application of subsurface drip irrigation with varying degrees of soil moisture depletion and its effects on the physical characteristics of soil as well as maize yield .

Three replications were set up using a split complete plot arrangement method using the RCBD complete block design. The secondary plots were treated with depletion levels, while the primary plots were subjected to irrigation techniques. The experimental boards in the field received the treatments at random. Each treatment had a 30%, 50%, and 70% depletion level. Three different watering systems were employed: surface drip irrigation, subsurface drip irrigation, and surface irrigation.

The highest number of leaves per plant, measuring 18.073 cm, was achieved with subsurface drip irrigation at a depletion level of 50%. This was followed by surface drip irrigation, which had an average of 16.579 cm, though the difference was not statistically significant. Additionally, the experiment revealed significant differences across the various treatments and levels studied for the number of rows per ear 17.767, the weight of 100 (48.35) grains of maize and the quantity of grains per row. The subsurface drip irrigation treatment at a 50% depletion level yielded the highest values for these metrics.

Keywords: surface and subsurface drip irrigation, maize

Introduction

The world is facing a severe water shortage, which will become more severe in the coming future. Therefore, more than one method and technique for irrigating crops has been developed and developed. Among these techniques is Subsurface drip irrigation, which is characterized by high efficiency in water productivity. Surface drip irrigation technique includes micro irrigation systems, often known as systems of low irrigation water flow. Irrigation (DI) and subsurface drip irrigation (SDI) are efficient techniques that enhance water productivity by minimizing plant water requirements through low water additions and high-frequency applications.

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These methods offer significant advantages, such as eliminating initial costs associated with land preparation and tillage, as plants are uprooted at the end of the season and new ones can be planted in the same location. Additionally, both DI and SDI contribute to substantial savings in fertilizer use. These distinct irrigation methods effectively meet plant water needs while conserving water and reducing wastage and losses. Precision irrigation systems require accumulated efficient management to control a number of common and important factors that affect the uniformity of irrigation water distribution, including the drip lines, their depth, their distance from one another, the distance between the drippers, the operating pressure, the dripper discharge rate, the frequency of irrigation, and the irrigation time (1)(2). The drip irrigation method has received international approval. It is distinguished by great irrigation and use efficiency, making it a useful technique for fertilizer and water rationing, and pipes may transport and distribute water with great efficiency without requiring drivers to create carrier channels.

For the plant to be productive during its growth stages and to be resistant to water stress in the soil, it need water. After rice and wheat, maize comes in third place in the strategy and is one of the commercially significant grain crops. Due to significant evaporation rates during the growth period in July, August, and September the hottest months of the year, it is crucial to implement effective irrigation scheduling. This strategy aims to provide plants with the optimal water needed to maximize crop yield while also maintaining soil moisture content close to the available water capacity. The aim is to compare and identify the effect of the three water addition techniques rather than subsurface drip irrigation on the characteristics studied.

Materials and methods:

The field experiment was carried out in a field located in the Qasim District of Babil Governorate during the fall season of 2022. The site is positioned at a latitude of 32º17'52" N and a longitude of 44º58'40" E, at an altitude of 31 meters above sea level. The experiment topographically level to semi-level with a slope of less than 1.2%. Sedimentary having a silty-clay loam texture, the field's soil was categorized under the major group Typic torrifluvent (3)(4 .(

Prior to planting, arbitrary soil samples measuring 36" in length and 14" in width were collected from various locations within the field at two depths (0.00-0.30 cm.(

The materials were crushed, allowed to air dry, and then sieved through a 2 mm sieve. As indicated in Tables (1) and (2), the samples were combined in some fashion, and a composite sample was obtained and utilized to evaluate the soil's chemical and physical characteristics.

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Table (1) Some physical properties of field soil before planting

Propriety	Soil depth
	0.20 – 0
Sand $g.kgm^{-1}$	26.41
Silt $g.kgm^{-1}$	39.7
Clay $g.kgm^{-1}$	33.9
Texture class	SiCL
Bulk density	1.33
Particle density	2.66
Porosity %	0.50
Void ratio	1.008
Water content at 33 kpa	0.33
Water content at 1500 kpa	0.13
Available water	0.20
Water conductivity	3.21

Table (2) Chemical properties of field soil before planting

Property	Unit	soil depth m
		0.20 – 0.00
EC_e	ds.m-1	1.57
PH	-	7.5
O.M	%	0.32
Ca+2	$mmol.l^{-1}$	2.8
Mg+		2.61
Na+		5.8
K+		0.72
So4-2		2.31
Cl-		4.51
HCo3-		1.81
Avil P	Ppm	6.94
Total N	%	1.71
CEC	(Cmol charge Kgm^{-1})	15.84
SAR	$(mmol.l)^{2/1}$	2.56

In the experiment, the water used for irrigation was analyzed and classified as C1 S3 according to the irrigation water guidelines (5)(6), as detailed in Table 3.

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Table (3): The chemical analysis of irrigation water

Property	Value
EC	0.77
pH	7.55
Ca^{+2}	3.55
Mg^{+2}	3.18
Na^{+}	2.82
K^{+}	0.13
Cl^{-}	2.08
SO_4^{-2}	4.59
CO_3^{-2}	4.8
HCO_3^{-1}	2.22
NO_3^{-1}	0.091
SAR	1.609
water Class	C_3S_1

Experiment Treatments and Statistical Design

Three replications and a strip-split-plot setup with a RCBD were used to organize the experiment. The main plots comprised the irrigation techniques treatments, while the subplots included the depletion level. Treatments were randomly assigned to the experimental plots. Data analysis was conducted using GenStat software, with the least significant difference set at the 0.05 level for comparing the arithmetic means of the coefficients. Table 4 presents the symbols for the coefficients used in the experiment, which include the following:

Systems of Irrigation:

.1Subsurface Drip Irrigation (SDI) technology, code A1

.2Surface Drip Irrigation (DI) technology, code A2

.3Surface Irrigation (SI), code A3

Second: levels of attrition

-1Depletion level 30% B1

-2Depletion level 50% B2

-3Depletion level 70% B3

Planting

Maize seeds (Zea Mays L.), a hybrid cultivar of Furat, were planted on July 22, 2022. Inside the panels, the planting was arranged arcuately. Every board had three mulches. Each mulch had seven plants, and there were 0.70 meters between rows and 0.25 meters between plants. On November 20, 2023 (growing season 120 days), the plants were harvested, with a total of 21 per plate of the experimental treatments.

Fertilization

In accordance with the fertilizer maize's advice, which called for adding 78.5 kg of phosphorus, 200 kg of nitrogen, and 120 kg of potassium H-1, fertilizers were added (1). Potassium sulfate (41.5% K) and DAP (18% N and 23.3% P) were employed. When the cultivation process began, the soil was prepared by adding DAP fertilizer and potassium sulfate. Two batches of urea fertilizer (46% N) were applied, the first fourteen days after planting, and the second thirty days later.

Plant parameters (growth and yield(

.1The number of leaves per plant (leaf -1(

For each experimental unit, a mean of seven plants was randomly selected from the guarded plants, starting from the first leaf at the soil surface and ending with the flag leaf (7)(8.(

.2Number of rows in the ear (ear-1(

The number of rows was calculated as an average of seven ears per experimental unit

.3Number of grains per row (grain row-1(

A random sample of seven ears was taken and the number of grains in each ear was calculated and the average was taken

.4Weight of 100 grains (Ton H-1.(

Calculated after sowing 100 grains from seven earwigs taken at random after drying the seeds and the humidity was constant at 15.5%, then weighed with a sensitive scale. (9)(10.(

Results and Discussion

Growth and Yield (Plant parameters(

.1The number of leaves per plant (leaf-1(

The findings in Table (5) indicate that the number of yellow corn leaves is significantly impacted by the treatments of irrigation systems and the degree of depletion, as the number of highest leaves reached, 18.073 For the, A1B2, the number of lowest leaves14.907 in A3B3. The average number of leaves was impacted by the irrigation treatments; the subsurface drip irrigation treatment A1B2 produced the most leaves on average (17.883), followed by the surface drip treatment, which had no difference. It is noteworthy that the irrigation treatment produced the lowest average number of leaves, 15,030, whereas the average number of leaves was 16.579. The subsurface drip irrigation system's superior average number of leaves can be attributed to the rhizosphere's uniform moisture distribution and the an abundance of irrigation water that results from establishing a favorable moisture balance at the right depth in the root zone. Furthermore, the sub surface drip irrigation system addressed the root zone's lack of sufficient moisture, which has an adverse effect on the plant's ability to absorb nutrients, such as NPK, and transport them through the soil, which in turn influences the plant's overall morphological traits, including leaf count. Water determines the number of leaves, and when compared to subsurface and drip irrigation treatments, the number of leaves decreased. Additionally, the average number of plant leaves decreased in surface irrigation treatment A3 when compared to subsurface drip irrigation treatment A1 and surface drip irrigation treatment A2. These findings aligned with the conclusions drawn (11)(12.(

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Table (5). The effects of irrigation systems and Depletion levels on leaf number

Depletion B	Irrigation system A			
	1	2	3	Average B
1	17.9	16.75	14.96	16.536
2	18.07	16.28	15.23	16.526
3	17.68	16.71	14.91	16.431
Average A	17.88	16.58	15.03	
L.S.D	A 0.511	B 0.511	0.8843	

-2

Number of rows in the ear (ear-1) The effects of irrigation system coefficients and depletion levels on maize are shown in Table irrigation treatments

.6The number of rows per ear of maize varied significantly, ranging from 14.513 to 17.768 rows per ear, according to the statistical study. This aligns with previous findings (13)(14), where the typical range was noted as 12 to 18 rows. The results indicated that the average number of rows increased in treatment A2 using subsurface drip irrigation compared to treatments A1(17.66) and A3(14.97) is significantly impacted. However, when 70% of the available water was depleted, the plants experienced water stress, leading to a decrease in the average number of rows(17.66,16.38,14.79)A1,A2,A3 consistent with results reported in studies (15)(16 .(

Table (6) Number of rows per ear

Depletion B	Irrigation system A			
	1	2	3	Average B
1	17.77	16.75	14.96	16.491
2	17.59	16.14	14.89	16.209
3	17.63	16.23	14.51	16.124
Average A	17.66	16.38	14.79	
L.S.D	A 0.275	B 0.275	0.4763	

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.3The Number of grains per row (grain row-1(

The effect of various irrigation methods and degrees of depletion on the quantity of grains per row for yellow corn is shown in Table 7. In row-148.2, treatment A1B2 yielded the most grains, whereas treatment A3B1 yielded the fewest, 41.43 grains. The amount of grains each row varied significantly depending on the treatments and how they interacted, according to the statistical study. It was observed that the coefficients of the irrigation systems significantly influenced the number of grains, with an average of 47.95 grains in treatment A1 and a lower average in treatment B1. Additionally, the effective rhizosphere area influenced grain yield according to the irrigation methods, consistent with findings from previous studies (17)(18 .(

Table. (7) Number of grains per row

Depletion B	Irrigation system A			
	1	2	3	Average B
1	48.2	45	41.43	44.78
2	48.35	45.35	42.63	45.34
3	47.3	44.17	42.68	44.92
Average A	47.95	44.84	42.25	
L.S.D	A 1.028	B 1.028	1.78	

.4weight of 100 grains

The weight of 100 grains of maize is significantly impacted by irrigation systems, according to the results in Table (8). The treatment of A1B2 registered the greatest value, 154.32, while the treatment of A3B3 recorded the lowest value .

The results of the statistical analysis showed that the highest rate of systems was 153.57 in A1 and the lowest rate in A3 was 143.35. This discrepancy in the trait's results is due to variations in irrigation methods, moisture contents, and irrigation durations, which were reflected in the treatments under study. Additionally, prolonged irrigation intervals resulted in a reduction in protein content, which in turn caused a decrease in the weight of 100 grains, which is in line with the findings (19)(20 1.((

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Table (8) Weight of 100 grains (µg grains -

Depletion B	Irrigation system A			
	1	2	3	Average B
1	153.8	149.2	143.7	148.89
2	154.3	147.9	144.1	148.78
3	152.6	147.1	142.3	147.32
Average A	153.6	148.1	143.4	
L.S.D	A 1.378	B 1.378	2.387	

References:

.1 Robi Borena, F. 2020. Effect of Drip and Furrow Irrigation at Different Irrigation Levels on Maize (Zea Mays L.) Yield, and Water Use Efficiency at Werner, Middle Awash, Ethiopia (Doctoral dissertation, Haramaya University.(

.2 Khuit, S. A., Al Ubori, R. S., & Al-Khafagi, K. F. H. (2023). EFFECT OF IRRIGATION PERIODS AND SOIL COVERING ON THE GROWTH AND YIELD OF TWO CORN CULTIVARS (ZEA MAYS L.). Ann. For. Res, 66(1), 558-573.

.3 Soil Survey Staff .2019. Soil Survey Manual (U.S. Department of Agriculture Handbook No. 18.(

.4 Hammad, H. M., Abbas, F., Ahmad, A., Bakhat, H. F., Farhad, W., Wilkerson, C. J., and Hoogenboom, G. 2020. Predicting kernel growth of maize under controlled water and nitrogen applications. International Journal of Plant Production, 14(4), 609-620.

.5 Logan, T. J. 2020. Sustainable agriculture and water quality. In Sustainable agricultural systems, pp. 582-613. CRC Press.

.6 Dehghanisanij, H., and Kouhi N. 2020. Interactive Effects of Nitrogen and Drip Irrigation Rates on Root Development of Corn (Zea Mays L.) and Residual Soil Moisture. Gesunde Pflanzen, 72(4), 335-349.

.7 Al-Halfi, Intisar Hadi Hamidi. And Atheer Hisham Mahdi Al-Tamimi. 2017. Response of three synthetic cultivars of yellow corn (Zea mays L.) to different fertilizers and some growth and biological yield traits. Iraqi Journal of Science and Technology, 8(3): 1652-1660.

.8 Cakmakci, T., and Sahin U. 2021. Improving silage maize productivity using recycled wastewater under different irrigation methods. Agricultural Water Management 255, 107051.

.9 Al-Sahoki, Medhat Majeed. 1990. Yellow maize production and improvement. Ministry of Higher Education and Scientific Research. Baghdad University.

.10 Bilgili, A. V., Yeşilnacar İ., Akihiko K., Nagano T., Hızlı A. A. H. S., and Bilgili A. 2018. Post-irrigation degradation of land and environmental resources in the Harran plain, southeastern Turkey." Environmental monitoring and assessment 190(11):1-14.

.11 Thamer, T. Y., Nassif, N., & Almaeini, A. H. (2021). The productivity of maize (Zea mays L.) water using efficacy and consumptive use under different irrigation systems. Periodicals of Engineering and Natural Sciences (PEN), 9(1), 90-103.

.12 Al-Mhmdy, Sh M., and Al-Dulaimy S. E. H.. 2018. Performance evaluation of drip irrigation system according to the suggested standards. The Iraqi Journal of Agricultural Science 49(1): 1099-1109.

.13 Ahmed, Shatha Abdel-Hassan. 2007. Response of two cultivars of sorghum to water stress under field conditions. PhD thesis. faculty of Agriculture . Baghdad University.

.14 Abbasi, Fariborz, Sohrab F., and Abbasi N. 2017. Evaluation of irrigation efficiencies in Iran. Irrigation and Drainage Structures Engineering Research 17(67): 113-120.

.15 Al-Roumi, Abdul Karim Hussein Al-Roumi. 2017 . Effect of distances between plants and irrigation duration on yield and its components of maize crop. Journal of Babylon University for Pure and Applied Sciences. Issue (1) Volume (25) p:87-108.

.16 Sengupta, K., Banik, N. C., Bhui, S., & Mitra, S. (2011). Effect of brassinolide on growth and yield of summer green gram crop. Journal of Crop and Weed, 7(2), 152-154.

.17 Ardaian, Marwan Majed Khaled. 2017. Estimation of genetic divergence and expression of drought tolerance gene LOS5/AB3 in the half-cross hybridization of corn Zea maize.L. Master Thesis . faculty of Agriculture . Anbar University.

.18 Abd, A. A. A. A. S., and AL-Zubaidy, A. H. (2022). Effect of irrigation periods and Brassinolide growth regulator on the yield and components of Maize (Zea Mays L.). Euphrates Journal of Agricultural Science, 14(2 .(

.19 Al-Shamari, M. F., Alkhateb B. A. A. H. and Mahmoud S. A. W. 2020. Role of compost and irrigation water quantity on some physical properties of soil under surface, subsurface drip irrigation. The Iraqi Journal of Agricultural Science 51(5): 1300-1307.

.20 Logan, T. J. 2020. Sustainable agriculture and water quality. In Sustainable agricultural systems, pp. 582-613. CRC Press.

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