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Effect of Different Irrigation Systems on Some Physical Properties of Soil, Growth and Yield of Cotton Crop

Abdullateef, Z. A.[1*]; A. M. El- Ghamry[2]; A. A. Jasim[1]; E. M. EL-Hadidi[2] and Dina A. Ghazi[2]

[1]Department of Agricultural Machines, College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq.
[2]Department of soil Sciences, College of Agriculture, Mansoura University.

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ABSTRACT

A field experiment was carried out to evaluate the effect of different irrigation systems on some soil physical properties, growth and yield of cotton crop in one of the experimental fields of the College of Agricultural Engineering Sciences, University of Baghdad in Jadiriyah / Baghdad in a sandy loam soil for the spring agricultural season 2021. Irrigation systems included surface drip irrigation, subsurface drip irrigation and furrow Irrigation systems as a control treatment were studied in this experiment. Soil moisture content, soil bulk density, soil moisture homogeneity coefficient, plant height and plant yield were measured in this study. Nested design was used under randomized complete block design (RCBD) with three replications. The superiority of the subsurface drip irrigation system ($LSD_{=0.05}$) in obtaining the highest soil moisture content stood 15.01%, the lowest soil bulk density stood 1.28 g cm^{-3}, the highest soil homogeneous Humidity Factor stood 95.73%, the highest plant height stood 121.75 cm, and the highest number of boll branches stood 13.10 branches $plant^{-1}$ and the highest yield stood 141.98 g $plant^{-1}$ Compared with surface drip irrigation system. Furrow irrigation excelled in obtaining the highest soil moisture content stood 20.51%, the highest plant height reaching 135.50 cm, and the highest number of boll branches reached 16.79 branches $plant^{-1}$ and the highest yield reaching 196.125 g $plant^{-1}$. Results obtained of this study improved our understanding regarding irrigation of cotton crop under arid and semi-arid conditions

Keywords: Drip irrigation system, sub-surface irrigation, soil moisture content, bulk density, crop productivity.

INTRODUCTION

The lack of water in Iraq is one of the determining factors for the production of agricultural crops, as Iraq suffers from the scarcity of surface irrigation water due to the lack of Iraq's share of the water of the Tigris and Euphrates by neighboring countries and climatic chinches (global warming), and the phenomenon of water scarcity requires solutions to provide irrigation water by the path to finding modern and high efficiency irrigation systems Al-Husseini *et al.,* (2014).

Researchers and scientists to worked seriously to reduce water losses by using modern irrigation systems for agricultural crops that consume large amounts of water, such as Rice and cotton crop, in a manner that ensures achieving a balance between consumption for all used sectors, A large amount of water, this large amount of water is difficult to provide in light of the scarcity of water resources, which exposes the cultivation of the cotton crop to restricting its cultivation or preventing cultivation, Jasim and Nafawa (2017), and Jasim *et al.,* (2020), and there is a need to use modern irrigation systems for planting cotton crop such as the surface drip irrigation system and the sub-surface drip irrigation system with high irrigation efficiency. The performance of these innovative systems for maximizing irrigation efficiency reaches high values (96%) relative to other developed irrigation systems (*e.g.* traditional drip irrigation and sprinkler irrigations) taking into consideration the partial watering of the root zone (Jasim and Al-Ruwashidi 2015). Besides, drip irrigation system showed high efficacy in developing soil physical properties and crop productivity (Bader *et al.*, 2010 and Elhindi, 2012).

Cotton occupies the second place after food crops in the world, which is of great economic importance for the use of its fibers in the manufacture of the finest types of textiles, and use in the manufacture of medical cotton, furnishings, clothing and vegetable oil industry. Furthermore, cotton seeds have several industrial applications including food oil (18-25% of the worldwide oil production), soap and feed given its high protein content (Ali Jabbar, 2011; Amer *et al.*, 2019). Cotton is one of the plants of indeterminate growth that tend to give abundant vegetative growth more than is necessary to produce fiber yield, due to the influence of many environmental factors and field operations, and this type of growth is undesirable, often causing sluggishness and increasing the possibility of falling flowers and young nuts. So, the aim of study to evaluate the effect of different irrigation systems on soil physical properties and productivity of cotton grown in a sandy loam soil.

MATERIALS AND METHODS

A field study was carried out in the open greenhouse of College of Agricultural Engineering Sciences - University of Baghdad during the spring agricultural season of 2021 to evaluate the effect of different irrigation systems on soil physical properties and productivity of cotton grown in a sandy loam soil. Random soil samples were collected

*** Corresponding author.**
E-mail address: zeyad.adnan@yahoo.com
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following the quartering of the experimental field. Representative soil samples were analyzed in the laboratory of Soil Dept., College of Agricultural Engineering Sciences, University of Baghdad. Some physical and chemical properties of the analyzed samples are illustrated in Table 1.

Table 1. Some physical and chemical properties of field soil.

Adjective		The Values	Unit of measure
Electrical conductivity EC (1:1)		1.4	$ds.m^{-1}$
Irrigation water salinity EC		1.1	$ds.m^{-1}$
PH 1:1		7.2	
The organic matter O M		7.8	$g.\ kg^{-1}$
Moisture water content at field capacity pv		38.25	%
Moisture water content at wilting point		23.00	%
Soil bulk density		1.23	$Mg.\ m^{-3}$
Particle sizes distribution	Sand	66.4	%
	Clay	14.8	
	Silt	18.8	
Soil texture class		Sandy Loam	Sandy Loam

The experimental design contains (randomized complete block design, RCBD with three replicates) three irrigation systems: (i) Surface drip irrigation systems (ii) Subsurface drip irrigation and (iii) furrow irrigation. Soil moisture content, soil bulk density, soil homogeneous Humidity Factor, plant height, plant number of boll branches and plant yield were measured in this experiment.

The experimental land was plowed using a mold bard plow with a depth of 30 cm and smoothed by using rotary harrows at a depth of 10 cm, and then leveled using a pelvic leveling implement. The experiment field was divided into three sectors; each sector included an irrigation system.

Subsurface drip irrigation system consists of a pumping unit, a main pipe diameter 3 inches, length 20 meters, a secondary tube diameter 2 inches, length 11.5 meters, and a branch tube diameter 2 inches, length 14 meters, number 3. The connections between the tubes, a control switch for opening and closing water number 3 and a plug. The end of 3 line and non-pressurized irrigation tubes (GR) made of plastics and containing drip inside, the distance between one drip and another is 40 cm. The tubes were placed under the soil with a depth of 15 cm, with 3 lines in the experimental unit and a length of 5 meters, the distance between one line and another is 75 cm and placed on one side tubes containing an upward dripper.

Surface drip irrigation system was used, which consists of a unified pumping unit, a main pipe diameter 3 inch, length 20 m, secondary pipe diameter 2 inch, length 11.5 m, number 1, branch pipe diameter 2 inch, length 14 m number 3, connections between the tubes, control switch for opening and closing water number 3, and a line end stopper. 3 non-pressurized irrigation tubes (GR) made of plastic and containing drips inside, the distance between one drip and another is 40 cm. The tubes were placed above soil surface, with 3 lines in the experimental unit and a length of 5 meters, the distance between one line and another is 75 cm, and the tubes were placed on the side of the tubes containing the drips down.

The furrow irrigation system (control treatment) was used, where three irrigation units were established for each experimental unit in the form of a trapezoid, as the dimensions of the upper base were 75 cm, the lower base was 50 cm, the height was 30 cm, and the length was 5 m for each meadow.

After completing the preparation of the field soil for cultivation and the installation of irrigation systems, the cotton crop (Has variety), was planted on 3/15/2021. The cultivation was in the form of lines, and the seeds were placed at depth of 4-5 cm in a hollow according to the planting distances at a rate of 3-4 seeds per hole and dimmed to one plant in the hole a week after emergence (Abd Ali and Al-Ansari, 1980). The distance between one hole and another is 40 cm, according to the distance between the surface and subsurface irrigation drips for non-pressurized tubes (GR) in the experimental units. The cotton crop was planted on both sides of the furrows and the distance between hole and another was 40 cm, in the experimental units, and the bush was controlled manually every ten days.

The compound fertilizer was added at a rate of (150) kg hectares^{-1} (NP K) in one batch when preparing the soil. Nitrogen fertilizer was added at an amount of (240) kg / hectare of urea (46% N) in two batches, the first after 3 weeks of planting and the second batch when flowering, Ministry of Agriculture - General Company for Industrial Crops, (2001).

The crop was irrigated for the purpose of completing germination and emergence without the use of irrigation systems, and after the emergence of the cotton crop, surface drip irrigation and subsurface drip irrigation systems were used, and then the amount of irrigation water was calculated during the season based on the moisture content of the soil and according to the directions (Ministry of Agriculture and Irrigation 1992).

Studied properties:

1- Soil moisture content %:

Soil moisture content was measured using a Soil Moisture Meter, after it was calibrated using the Gravimetric Method and using the equation proposed by Gardner, (1965).

$$Pw = \left(\frac{Msw - Ms}{Ms}\right) x 100\ \%$$

Pw = gravimetric soil water content (%).
Msw = moist soil weight (g).
Ms = dry soil weight (g).

Following the equation below the volumetric moisture content was calculated as described by Hillel, (1980).

$$Pv = \frac{Pw}{100}\ x\ \frac{Pb}{lw}$$

Pv = volumetric moisture content, %
Pb = bulk density of the soil, Mg m^{-3}.
Lw = Density of water Mg. m^{-3}

2-Soil bulk density, Mg .m^{-3} :

The bulk density was calculated according to the Core Method cylinder using the following equation and suggested by Black and Hartage (1986).

$$Pb = \frac{Ms}{Vt}\ \ Mg.m^{-3}$$

Pb = bulk density Mg . m^{-3}
Ms = mass of the dry sample 1 µg.
Vt = sample volume m^3.

3-Homogeneous Humidity Factor %:

The consistency coefficient of the homogeneity and distribution of the water emanating from the sprinkler and the drippers is calculated during the equation that was developed by the researcher, Christiansen (1942).

$$Cu = \frac{1 - \sum s}{mn} \ x\ 100$$

Cu = homogeneous humidity factor %.
s= sum of the absolute deviations from the mean discharge, ml. min^{-1}.
m= drip average discharge, ml. min^{-1}.
n=distribution of cans.

Plant measurements :

Representative plants (10 plants) were randomly chosen from the median lines of the experimental unit, leaving the sentinel lines for the following measurements:

1 Plant height (cm): It was measured by taking the average height of the main stem from the surface of the soil to the top of the plant for the longest branch at the harvest stage of the previously specified plants.
2 The number of fruiting branches in a plant: a branch/plant, which was calculated by taking the average number of fruiting branches in the plant at the stage of harvesting for the predetermined plants.
3 Cotton blossom yield (hair), grams per plant: The sum of the yield of fairies from cotton hair by taking the yield of pre-determined plants from each experimental unit calculated in grams for each plant.

RESULTS AND DISCUSSION

1-Soil moisture content (%):

Subsurface drip irrigation system showed superiority for obtaining the highest moisture content (15.01%) relative to surface drip irrigation system (14.04%). These results are in harmony with those obtained by Jabr *et al.,* (2020).

2-Soil bulk density (мg /m³):

The Table (2) also shows the effect of irrigation systems on the soil bulk density. It shows that there are significant differences between the averages of irrigation systems, as the subsurface drip irrigation system obtained the lowest value for the soil bulk density, which amounted to 1.28 мg m^{-3}, compared to the surface drip irrigation system, which obtained the highest value of 1.40 мg / m^{3}, and the reason may be exposure The soil pressure (compacting), and the increase in the operational pressure of the irrigation system, and these results are in agreement with the results obtained (Jasim and Al-Kaabi, 2017 and Al-Ruwaishdi, 2014).

Table 2. Effect of irrigation systems on some physical properties of soil.

Irrigation system	Soil moisture content %	Soil bulk density (мg /m³)	Homogeneous humidity factor %
surface drip irrigation	14.04	1.40	91.50
subsurface drip irrigation	15.01	1.28	95.73
Furrow irrigation	20.15	1.30	93.55
LSD=0.05	0.23	1.01	0.615

3-Homogeneous humidity factor (%):

The Table 2 shows the effect of irrigation systems on the soil moisture homogeneity coefficient. The table shows that there are significant differences between the averages of irrigation systems, as the subsurface drip irrigation system outperformed in obtaining the highest percentage of the soil moisture homogeneity coefficient of 95.73%, while the superficial drip irrigation system obtained 91.15%, and the reason may be the increase in the operating pressure of the irrigation system Drip and drain the water from the drippers equally, and these results agree with the results obtained (Al-Ruwashidi, 2014 and Capra and Scicolone, 1998).

4-Plant height, (cm):

Table 3 shows the effect of irrigation systems on plant height. It shows the superiority of the subsurface drip irrigation system significantly in obtaining the highest value of plant height, which was 121.75 cm, while the superficial drip irrigation system obtained 119.25 cm. In the root area, this leads to the plant cells not experiencing any tension, so its leaves are not wilted and erect, which increases its vitality and height. The highest plant height reached 135.50 cm.

5- Plant number of boll branches, (branches plant^{-1}):

Table (3) also shows the effect of irrigation systems on the number of fruiting branches, as the table shows the superiority of the subsurface drip irrigation system significantly in obtaining the highest value of the number of fruiting branches amounted to 13.10 branches.plant^{-1}, while the super surface drip irrigation system obtained 12.61 branches Plant^{-1}, and the reason may be that the drip irrigation system under the soil surface provides moisture at the best levels in the root zone, and adequate preparation of plant nutrients in the root zone, which increases its vitality, height and production. These results are consistent with the results obtained by Jabr et al., (2020), and when comparing with the furrow irrigation treatment, it was clear that furrow irrigation was superior in obtaining the highest number of boll branches, which amounted to 16.79 branches.plant^{-1}.

6-Cotton yield (hair), (g. plant^{-1}):

The Table 3 shows the effect of irrigation systems on the yield of flowering cotton. It shows the superiority of the subsurface drip irrigation system significantly in obtaining the highest value of the weight of the flower cotton crop, which reached 141.98 g. plant^{-1}. while the superficial drip irrigation system obtained 136.11 g.plant^{-1}, The reason may be that the subsurface drip irrigation system provides moisture at its best level, and these results are consistent with the results obtained by Al-Fartousi (2004), and Jabr *et al.,* (2020), and when compared with the furrow irrigation treatment, it was found that the furrow was superior in obtaining the highest weight of the cotton yield, which amounted to 196.125. g. plant^{-1}.

Table 3. Effect of irrigation systems on some plant properties.

Irrigation system	plant height, cm	Plant number of boll branches, branches. Plant^{-1}	cotton yield, g plant^{-1}
surface drip irrigation	119.25	12.61	136.11
subsurface drip irrigation	121.75	13.10	141.98
Surface irrigation	135.50	16.79	196.12
LSD=0.05	1.413	0.349	3.58

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the above results, it was concluded the superiority of the subsurface drip irrigation system in obtaining the highest soil moisture content, the lowest value of the bulk density of the soil, and the highest soil moisture homogeneity coefficient ratio compared to the surface drip irrigation system, while the furrow irrigation system obtained the highest plant height and the highest number of fruit branches. And the highest score.

Using subsurface drip irrigation and surface drip irrigation systems were recommended because of that regulate the quantities of added water in the event of water scarcity, and the use of other irrigation methods and other types of tubes, drippers and other types of cotton under different soil textures is recommended.

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تأثير نظم ري مختلفة علي بعض الصفات الفيزيائية للتربة ونمو محصول القطن

زياد عدنان عبد اللطيف[1]، ايمن محمد الغمري[2]، عبد الرزاق عبد اللطيف جاسم[1] ، السيد محمود الحديدي[2] ودينا عبد الرحيم غازي[2]

[1]قسم المكائن والالات الزراعية، كلية علوم الهندسة الزراعية، جامعة بغداد، العراق

[2]قسم علوم الاراضي، كلية الزراعة، جامعة المنصورة. مصر

الملخص

نفذت تجربة حقلية لغرض معرفة تاثير انظمة ري مختلفة علي بعض الصفات الفيزيائية للتربة ونمو والحاصل لنبات القطن في احد حقول كلية علوم الهندسة الزراعية في منطقة الجادرية / بغداد في تربة سلتية رملية للموسم الزراعي الربيعي 2021. تم دراسة انظمة الري والتي تضمنت نظام الري بالتنقيط السطحي ونظام الري بالتنقيط تحت السطحي والري السطحي بالغمر .تم قياس كل من المحتوى الرطوبي للتربة والكثافة الظاهرية للتربة ومعامل التجانس الرطوبي للتربة وارتفاع النبات وعدد الافرع الثمرية وحاصل النبات في هذه التجربة. استخدم التصميم المعشش Nested Design ضمن نظام القطاعات العشوائية الكاملة RCBD وبثلاث مكررات، وتم مقارنة متوسطات المعاملات باستعمال اقل فرق معنوي تحت مستوى احتمال 0.05 ($LSD_{=0.05}$) . ويمكن ايجاز النتائج كما ياتي: تفوق نظام الري بالتنقيط تحت السطحي في الحصول على اعلى نسبة محتوى رطوبي للتربة بلغت 15.01% واقل قيمة للكثافة الضاهرية للتربة بلغت 1.28جم.سم$^{-3}$ واعلى نسبة لمعامل التجانس الرطوبي للتربة بلغ 95.73 % واعلى ارتفاع للنبات بلغ 121.75سم واعلى عدد افرع ثمرية بلغ 13.10فرع.نبات$^{-1}$ واعلى حاصل بلغ 141.98غم.نبات$^{-1}$. مقارنة بنظام الري بالتنقيط السطحي الذي حصل على اقل نسبة محتوى رطوبي للتربة بلغ 14.04% واعلى كثافة ضاهرية للتربة بلغت 1.40جم.سم$^{-3}$ واقل نسبة لمعامل التجانس الرطوبي للتربة بلغت 91.5% واقل ارتفاع للنبات بلغ 119.25سم واقل عدد افرع ثمرية بلغ 12.61فرع.نبات$^{-1}$ واقل حاصل بلغ 136.11غم.نبات$^{-1}$. بينما تفوق نظام الري بالغمر في الحصول على اعلى نسبة محتوى رطوبي للتربة بلغت 20.51% واعلى ارتفاع للنبات بلغ 135.50سم واعلى عدد افرع ثمرية بلغ 16.79فرع.نبات$^{-1}$ واعلى حاصل بلغ 196.125غرام.نبات$^{-1}$.