EFFECT OF LENGTHANDDEPTHOF THEDRIPTAPEON WETTING FRONT ADVANCE IN THE ROOT ZONE OF SUNFLOWR USING HYDRUS 2D/3D PROGRAM

Zahraa K. K. Al- Salihi **Salloom B. Salim**
Researcher **Assist. Prof.**
Dept. of Soil Sci. and Water Resour. Colle. Agric. Engin. Sci - University of Baghdad.
Samaalsalihi456@gmail.com salloom.salim@coagri.uobaghdad.edu.iq

ABSTRACT

A field experiment was carried out during the spring season 2020 at the University of Baghdad to study the effect of the length and depth of the drip tape on wetting advance ofsubsurface drip irrigation system using Hydrus 2D/3D program. The site was planted with sunflower in a clay loam texture. The drip tape was installed at 0.3m below soil surfacein two lengths; 20m and 40m. The experiment was designed according to the arrangement of split plotsdesign and with three replications. The treatments were randomly distributed and planted with sunflower crop. The results showed that the moisture contents of the 20 mlength drip tape was higher compared with the 40 m drip tape length. Also, the length of the tape was superior in some components of the yield if the length of the drip tape exceeded 20 m in the character of the number of seeds in one disc, and the result was a significant superiority.

Keywords: Hydrus-2D/3D, subsurface drip irrigation, seeds yield, irrigation management.
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تأثير طول وعمق شريط التنقيط في تقدم جبهات الترطيب في المنطقة الجذرية لزهرة الشمس بأستعمال برنامج Hydrus 2D/3D

زهراء خالد كامل الصالحي **سلوم برغوث سالم**
الباحثة **أستاذ**
قسم علوم التربة والموارد المائية – كلية علوم الهندسة الزراعية – جامعة بغداد

المستخلص

نفذت تجربة حقلية خلال الموسم الربيعي 2020 في جامعة بغداد لغرض معرفة تأثير طول وعمق شريط التنقيط على جبهات الترطيب لمصدر التنقيط تحت سطح التربة وباستعمال برنامج Hydrus 2D/3D ، كذلك دراسة تأثير طول الحقلي في المحتوى الرطوبي في التربة. تم زراعة محصول زهرة الشمس في تربة ذات نسجة مزيجة طينية Clay Loam وللعمق 0–30 سم وصممت التجربة على وفق ترتيب الالواح المنشقة بتصميم القطاعات بثلاث مكررات وزعت المعاملات بصورة عشوائية وزرعت بمحصول زهرة الشمس. أظهرت النتائج توفق المحتويات الرطوبية للتجربة طول شريط التنقيط 20م مقارنتاً طول شريط التنقيط 40 م، و تفوق طول الشريط في بعض مكونات الحاصل أذ تفوق طول شريط التنقيط 20م في صفة عدد البذور في القرص الواحد والحاصل تفوقاً معنوياً.

الكلمات المفتاحية : هايدرس ثنائي وثلاثي البعد، الري بالتنقيط تحت السطحي، حاصل البذور، أدارة الري

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INTRODUTION

Irrigation is one of the most important things to increase agricultural production in different parts of the world, and it is more important in dry and semi-arid areas, as the precipitation is not sufficient to meet the needs of the plant and reach the stage of economic production. Increasing competition for fresh water sources between civil, industrial and agricultural calls for a visit to the efficiency of water use through improving irrigation scheduling, irrigation time and the amount of water added during the growing season. However the implementation of an efficient irrigation plan is empirically not possible due to the multiplicity of variables that must be taken into consideration. It includes climate, type of crop, determinants of irrigation systems and the use of soil and water sensor technologies that have a direct impact on improving water management. It also needs to focus on determining the spatial change in evapotranspiration (ET) and water addition(12). In the early days of irrigated agriculture, farmers and specialists were still behind the technology or concept of improving the use of water. One of these concepts was the on-site addition of water directly to the root zone. The second concept was subsurface drip irrigation ,which does not (reduce) evaporation losses from the soil surface. Subsurface irrigation is defined as adding water below the surface of the soil through drips for discharge equal to the duration of drip irrigation when the moisture of the root zone from rain or the contribution of ground water is not sufficient to meet the needs of the plant and the deficit may be for the whole or part of the growing season, which requires adding water to fill the deficit when Reaching the critical THRESHOLD (7). The depth of the drip tape below the soil surface is an essential SDI design factor. Determining the depth of the drip tape depends on the shape and size of the wetting area in the soil, which is mainly a function of the structure and texture of the soil, discharge, the distance between the drips and the characteristics of the plant roots (15). the increase in the depth of the drip tube under the soil surface increases the deep permeation by a high percentage compared to the decrease in evaporation, which results in a decrease in irrigation efficiency and that the water consumption decreased by 7% when the irrigation system was at a depth of 20 cm below the soil surface. Estimating the effect of the length of the tape of the drip irrigation system on the values of the consistency and distribution of water in the drip irrigation systems is one of the important matters in the management of irrigation water by increasing the consistency and decreasing the values of the roughness coefficient, as the friction losses increase by increasing the operating pressure when it is fixed throughout the drip tapes, as it is known that drip irrigation It does not irrigate the entire root zone (wetting front) and has drainage rates under low pressure. For this, work on designing drip irrigation systems is required. This is done after selecting the dripper (drain and compress) (4). The network diagram also includes the number of total units as well as the length of the main and secondary drip tubes. The droplet discharge rate depends mainly on the consistency value and the perfusion efficiency. Therefore, the required consistency of the flow network must be obtained, depending on the pressure and discharge of the droplet, and that the drain is sensitive to any change in pressure(6). Hydrus 2D/3D is one of the programs for simulating soil moisture through subsurface irrigation drippers (Window-based Program), which employs the computational power of computers in turn, solves numerical models that describe water-soil-plant relationshipsin saturated and unsaturated systems to analyze precision irrigation systems, Therefore, it was widely used in simulating the movement of water, salt, heat and root extension in SUP SSDI system in two dimensions in porous media with variable saturation and under variable boundary conditions(10) and (18). (Helianthus annuus L.)Sunflower is one of the important oil field crops, as it is a crop that is grown on large areas and therefore high amounts of oil can be obtained from it. This crop has an ideal growth period, which ranges from 90-120 days, in addition to its tolerance to high temperatures, which Making it one of the important summer crops in Iraq. The sunflower crop is distinguished by its high amounts of oil ranging from 34-52% and protein 12-14%, and the quality of its oil is good due to its high linoleic acid content and low cholesterol, so it is considered one of the important summer crops in Iraq. Its oil is good for human consumption (13).

Thisstudy came with the aim of

Effect of drip depth on wetting fronts of drip source below the soil surface using Hydrus 2d/3d program, and study of the effect of field tube length on moisture content of clayey mixed texture soil.

MATERIALS AND METHODS

Location and configuration of the experience: A field experiment was carried out to grow the sunflower crop of the Shamus variety in one of the research fields of the College of Agricultural Sciences / University of Baghdad in Jadiriyah (station F) near the calculator center and at latitude 33º16/28.41"N, on longitude 44º23/26.11"East, at an altitude of 34 meters above sea level, the field soil was classified as having a clay texture of 0-30 cm depth (Clay loam; Strong fine, Typic,Torrifluevents)(19).Explainsthe study site is characterized by a flat topography that was previously planted with annual oil crops and left for one season. The soil of the field was plowed with a perpendicular plow to a depth of 0.30 m, and the soil was smoothed with disc harrows and an initial leveling was done using a trowel and a raker. Replicators and open myros in the replicates and the depths of the bottom of the mezze were set 0.15 m and 0.30 m, and the distance was 0.75 m between one mere and another, and the gradient level was zero and the number of eight mezs was divided for each repeater. A distance of one meter longitudinal and transverse was left in order to prevent interference between the treatments, and the number of units in the experiment was forty-eight experimental units.

Physical and chemical properties of fieldsoil

Samples were taken randomly from several locations of field soil at a depth of 0.00-0.30m. The samples were mixed, and the soil was pneumatically dried in the laboratory and then ground and sieved through a sieve with a diameter of 2 mm. This sample was used for the purpose of estimating the physical and chemical properties of the field soil before planting, as shows in Table (1, 2).

Table 1. Physical analyzes of soil

Properties	units	Depth (+30)
Sand	g Kg^{-1}	344
Silt		348
Clay		308
Soil texture		Clay Loam
Bulk Density	Mgm^{-3}	1.46
Particle Density		2.65
Total porosity	---	0.45

Table 2. Chemical analyzes ofsoil

Properties	Units	Depth(+30)m
pH	---	7.45
EC	dSm^{-1}	1.91
Ca^{++}		14.0
Mg^{++}		5.5
Na^{+}		33.23
K^{+1}	Meq L^{-1}	0.71
SO_4^{-2}		11.61
Cl^{-1}		3.0
HCO_3^{-1}		3.5
NO_3^{-1}		24
PO_4^{-2}		2.4
SAR	$(mgL^{-1})^{-1/2}$	3.12
CEC	Cmol kg^{-1}	7.16
O.M	g Kgm^{-1}	7. 0
$CaCO_3$		231.1

Experiment parameters amd statistical design: Two parameters were used in the experiment: the length of the drip tape and the depth of the drip tape. Using subsurface drip irrigation systems. The experiment was designed according to randomised complete block desing within plot threeplicun replications, the transactions were distributed randomly and on the lines within the field.

Drip irrigation system

The drip irrigation system for the study site consists of a water tank with a capacity of 5000 liters and is connected to an additional tank with a capacity of 5000 liters, an electric pump of 2 horsepower, valves to open and close the water, a pressure gauge, a filter, a fertilizer for fertilizing plants and a water meter. Branching from the main tube secondary tubes (field tubes) the diameter of the secondary tube 0.016 m. Use the tube to supply water for the subsurface drip irrigation system. Equip each secondary tube with a valve and two gauges to control the pressure and water discharge. Branching from each main tube to eight field irrigation tapes for each repeater, each treatment was equipped with a tape tube below the soil surface. The length of the tape was 40 m, the number of drippers was 400, the length of 20 m, the number of drippers was 200, the distance between the drippers was 0.10 m, and the drip irrigation pipe was placed under the surface at two depths of 0.15 and 0.30 m. These pipes supply water for each of the experiment parameters, thus bringing the number of field pipes to 24 for each length. The irrigation system was arranged according to what was mentionedin(9).

The process of cultivation

The Shamoos flower was planted in Gore for the planting season, dated 1/3/2020. Surface drip irrigation was carried out when 3-4 leaves of the plant were completed, it was switched to sub-surface drip irrigation .The vegetative growth traits of the sunflower crop were measured. Five plants were selected from each experimental unit to measure the height of the plant, the number of leaves per plant, the number of seeds in the disc and the total yield

Irrigation process

The drip irrigation process was carried out when the soil moisture content reached 50% of the ready water exhausted by adding the water depth needed to reach the moisture content at the limits of the field capacity of the field soil using the soil moisture description curve for the field capacity values. The depth of irrigation water to be added was also calculated from the equation proposed before(5).

$$d = (\theta_{f_c} - \theta_w) \times D$$

Whereas:

d = depth of water added (mm).

θ_{fc} =Volumetric moisture content at field capacity ($cm^3 cm^{-3}$)

θ_w =Volumetric moisture content before irrigation ($cm^3 cm^{-3}$).

D =Soil depth which is equal to the effective rootstock depth (m)

Theoretical basis for hydrus 2d/3d

The easiest model to simulate the distribution and redistribution of water in the subsurface drip irrigation system SDI is the planar two-dimensional model, in which the terminal drip tube represents a point source in a two-dimensional field and the terminal represents an undefined linear source in a direction perpendicular to the plane. simulation. This model of flow occurs in cases where the wetness front overlaps between the dots and merges to form a regular flow line along the drip tube. Hydrus 2D was used to simulate the distribution and redistribution of water(17)and the Richards equation(16) considers the following It is the governing equation for describing the movement of water in two directions:

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[k(h)\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial z}\left[k(h)\frac{\partial h}{\partial z} + k(\theta)\right]$$

Since:

θ = Volumetric moisture content ($L^3 L^{-3}$)

h = soil water column pressure (L)

t = time and x = horizontal coordinate and z = vertical coordinate

k = hydraulic conductivity(LT^{-1})

Estimation of hydraulic coefficients

To estimate the variables of the Van Genuchten-Mulaem model (θr, θs, α, N, Ks) Rosetta Lite version 2003 is used. It is a computer program included in the Hydrus2d/3d software package that consists of several models based on a neural network used to estimate hydraulic parameters from tissues and related data Table (3) shows the expected variables of the Van Genuchten-Mulaem model (20) used in simulation.

Table3. Soil moisture characterization curve predicted by Hydrus 2D/3D

N		1.264
ά	(cm^{-1})	0.0367
θ_s	($cm^3\ cm^{-3}$)	0.4211
θ_r	($cm^3\ cm^{-3}$)	0.0918
K_s	($cm\ h^{-1}$)	0.531

The characteristics of the studied growth:

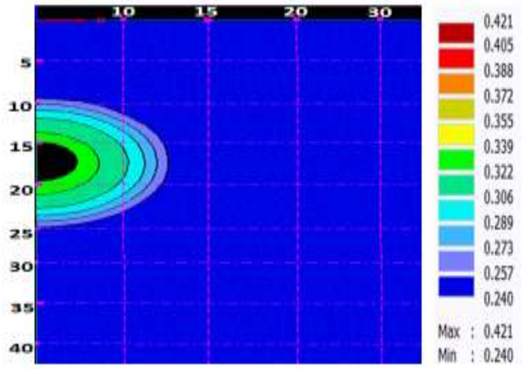
The growth characteristics of the vegetative growth of the apricot flower were measured for each of the experimental treatments, and five plants were selected from each experimental unit. The studied indicators were as follows.

Average total number of seeds in one disk and seed yield.

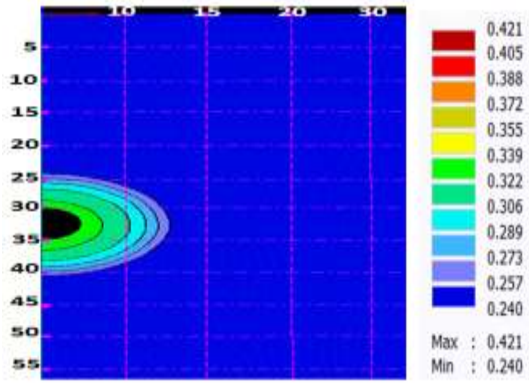
RESULTS AND DISCUSSION

theeffectof depthonthe size of the wet area

Figures 1 and 2 illustrate the variation in wetting depth when using droplet depths 0.15 and 0.30 m below the surface of clay loam texture soils. That the water (moisture depth of the dripper should be at a shallow depth for medium soils and at a content) did not reach the surface of the soil, in general, the ideal deep depth for coarse soils, but the depth of the plant roots must be taken into account where the depth of the dripper is appropriate to the depth of the plant roots in order to ensure that water reaches straight to the root total. It was observed that the depth of wetting increases with the depth of the dot, but it had no effect on the radius of the wetting area. If the depth of the droplets is shallow or close to the soil surface, it reaches the surface by capillary action and the wetting pattern expands to the soil surface, this role leads to increased water loss through evaporation. On the other hand, as the depth of the deeper dripper reduces evaporation but will raise the seeping water (water filtration). Accordingly, it was noted that the coefficient of determination of the clay soil formula may be affected slightly in the absence of the droplet depth to 84.93%, while the coefficient of determination remained constant in the absence of a drip depth for other soils, and therefore all equations can be neglected except for clay soils. I agree with(3).



Clay Loam,Tmie 4 hr Emitter depth 15cm



Clay Loam,Tmie 4 hr Emitter depth 30cm

Fig.1. Simulation of the wetting pattern of the dotted depth below the surface of clay soil after 4 hours for a 20 m length experiment.

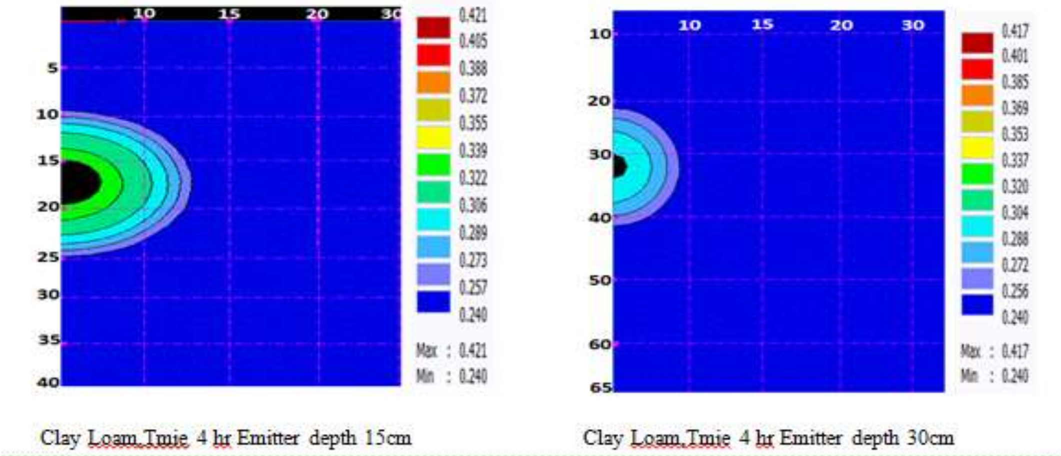
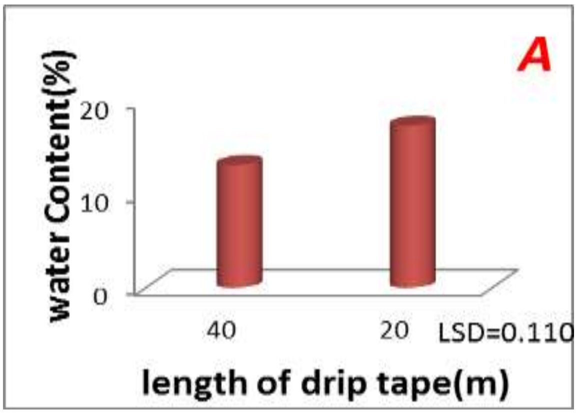


Fig. 2. Simulation of the wetting pattern of the dotted depth below the surface of clay soil after 4 hours for a 40 m length experiment.

Effect of field tube length on moisture content : Figure 3 shows the effect of the length of the drip tape on the moisture content, as it was significant in the moisture content when the field tube length decreased. Whereas, at the beginning of the agricultural season, the treatment of drip tape length of 20 meters recorded the highest value by 17.61% compared with the treatment of drip tape length of 40 meters, which gave 13.14%. At the end of the agricultural season for sunflower crop, the values were 17.92% and 12.78% for the treatment, the length of the drip tape was 20 and 40 meters, respectively. The reason for the increase in moisture content with a decrease in the length of the field drip tube is to increase the homogeneity of the drip drainage by decreasing the length of the drip tube, and thus increasing the diameter of the humidification area with the decrease in the length of the field tube, which leads to an increase in the moisture content of the soil(1). The significant superiority of the field tube length 20 meter treatment with the 40 meter long treatment continued in increasing the moisture content at the end of the agricultural season. The relationship between moisture content and the length of the field tube was expressed in a straight line relationship in two equations (4) (5) and with a coefficient of determination of 0.998 and 0.997 at the beginning of the season and the end of the agricultural season, respectively, from which the increase in soil moisture content is evident by the decrease in the length of the field tube(8) $Pwi=21.582 - 0.211\ L$ ($R2=0.998$) $Pwe=23.062 - 0.257\ L$ ($R2=0.997$)



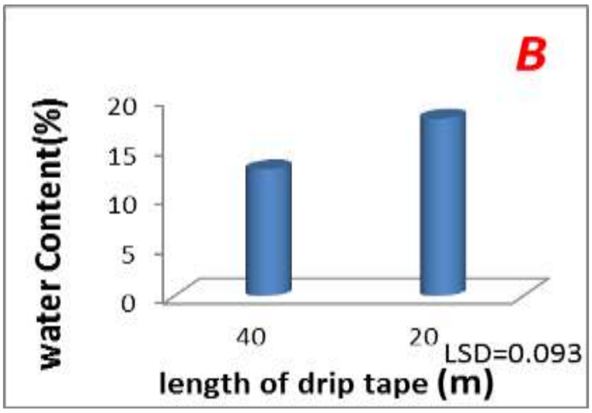


Fig. 3. Effect of field tube length (m) on soil moisture content (%) (A) at the beginning and (B) at the end of the growingseason

Specifications Of The Vegetative

The number of seeds in one disk(one disk seed) : It includes the total number of filled and empty seeds in the disc. The results of the analysis of variance table in the experiment of the length of the drip tape 40 meters show that there is no significant effect of the parameters of water quantity and effort, with a significant effect between the combinations that overlap water quantity and effort with depth in the average number of seeds in the sunflower disc. Whereas, the T2 (constant voltage and water quantity) treatment achieved the highest mean of 1286.33 ($disc^{-1}$ seed) and the lowest mean for T2 (variable water quantity and constant voltage) was 1188.71 ($disc^{-1}$ seed). Also there was no significant effect between the depths of 1265.11 and 1211.08 (seed $disc^{-1}$) at depths of 0.15 and 0.30 m. Also there were no significant differences between the overlapping combinations, where 1368.0 (seed disc^{-1}) gave the highest average for the combination of constant water quantity and voltage at 0.15 m depth, and gave the same depth the lowest average variable water quantity and a constant voltage of 1162.3 (seed disc^{-1}). As for the experiment with the length of the drip tape 20 m there were no significant differences between treatments and combinations overlapping with depth, the T3 treatment (variable amount of water and variable effort) was characterized by the highest average for this trait amounting to 1410.15 (seed disc^{-1}) while the treatment T1 (constant water quantity and variable effort) gave The lowest mean of the trait was 1253.15 (seed disc^{-1}). Noting that there were no significant differences for the two depths (0.15 and 0.30) m, which amounted to 4.85138 (seed disc^{-1}), the highest average depth was 0.15 m, and the lowest average depth was 0.30, which amounted to 1323.5 (seed disc^{-1}). A significant effect was found between the interaction combinations, the amount of water and effort with depth. It reached 1437 (seed disc^{-1}). The highest average number of seeds per disc at the depth is 0.15 m for a combination of constant variable water quantity and variable voltage, and the lowest average for this characteristic was 1111.2(seed disc^{-1}) for a quantity combination. Constant water and variable voltage and at a depth of 0.30 m. The reason for the decrease in the number of seeds with decreasing amounts of water is attributed to the insufficient opportunity for fertilization and the result of the adverse effect of water stress, which causes the seeds to abort by not holding them and contributes to their reduction. Stress also affects the small size of the disc, thus affecting the number of seeds in the disc(2)ز

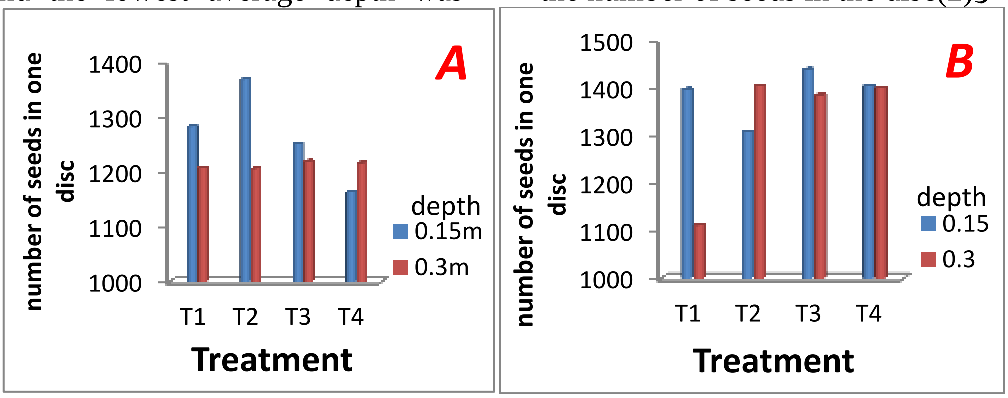
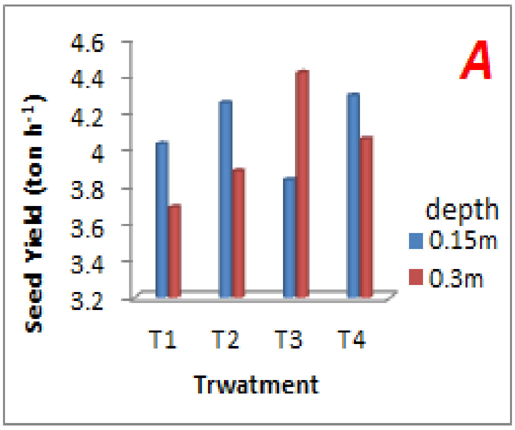


Fig.4.The number of seeds per disc of sunflower crop (A) for an experiment with a length of 40 m, (B) for an experiment with a length of 20 m

Seeds yield (ton.h^{-1})

It is clear from the results of the analysis of variance table that there were no significantdifferencesbetween the averages due to the effect of the parameters of water quantity and structural stress in the study season and the interaction between them, and there was no significant effect of the interaction combinations in this trait in the season of planting, sunflower crop for the experiment, the length of the drip tape was 40 m. The T2 treatment (constant water quantity and constant structural effort) was characterized by the highest mean yield of 4.202 ton.ha^{-1}, and it gave the lowest mean when the T1 treatment (constant water quantity and variable structural effort)was 3.858 ton.ha^{-1}. Also, there was no significant effect between the two depths (0.15 and 0.30) m, where the depth was 0.15 m, the highest average was 4.168 tons ha^{-1} and the lowest average at depth 0.30 m was 4.009 ton ha^{-1}, noting that there were no significant differences between the interaction combinations between the treatments With the depth, it was 4.520 ton ha^{-1}, the highest average for the combination of overlapping water quantity and structural effort was fixed at 0.15 m depth, and the lowest average was 3.687 ton ha^{-1} at depth of 0.30m.As for the drip tape length experiment of 20 m, it is noted that there is a significant effect between the parameters of water quantity and effort, as well as the presence of significant differences between the interference combinations with depth. The T4 treatment (water quantity and structural stress are variable) had the highest average seed yield of 5.148 tons ha^{-1}, and the lowest average was 4.149 tons ha-1 for T2 treatment (the amount of water is constant and the structural effort is constant). Noting that there was a significant effect between the interference combinations with depth, which amounted to 5.321 tons ha^{-1}, the highest average of seed yield for the overlapping combination, the amount of water is variable and the structural stress is constant at depth 0.15 m, and it gave 3.902 tons ha^{-1} the lowest average for the combination of constant water quantity and constant structural effort at depth 0.30 m.Iagree with(14**).**



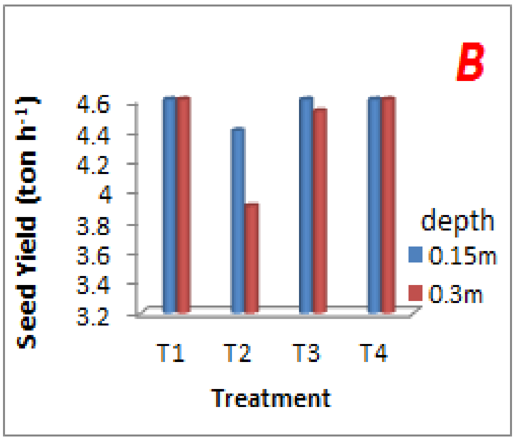


Figure 5. The total yield of sunflower crop (A) for an experiment with a length of 40 m, (B) for an experiment with alength of 20 m

CONCLUSIONS

The results showed studies and research in the field of drip irrigation system design by introducing some other criteria for the irrigation system, building relationships and making use of the equations of straight line and polynomial regression obtained from linking the length of field pipes and moisture content with a specific drainage and the drips and the distance between the drippers to determine the best hydraulic design of the systems according to the characteristics of the soil and the type of soil. cultivated plant. Taking into consideration the water characteristics of the soil, the drainage and the appropriate depth of the subsurface drip irrigation system as basic design factors, and the irrigation time is determined by the time required for the wetness front to reach the horizontal and vertical dimensions of the root zone. As the effect of the length of the field tube on the moisture content increases the moisture content by decreasing the length of the drip irrigation pipe. With the superiority of the yield and the number of seeds in the disc for the experiment, the length of the drip tape is 20 m.

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