Jurnal
Teknologi

Full Paper

THE EFFECT OF THREE DEPTHS OF SUBSURFACE DRIP IRRIGATION LEVELS WITH TWO TYPES OF SOIL ON THE PERCENTAGE OF SOIL MOISTURE CONTENT

Article history
Received
11 November 2021
Received in revised form
27 March 2022
Accepted
13 April 2022
Published Online
20 June 2022

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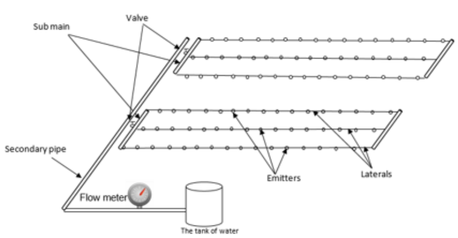
Graphical abstract



Abstract

The experiment was carried out in the educational nursery field of Department of Plant Production Technologies / Mosul Technical Institute during the agricultural season 2019-2020, to study two factors; the first is studying the effect of three depths, 5 cm (T1), 10 cm (T2) and 15 cm (T3), using Subsurface Drip Irrigation (SDI) The second factor is studying two types of sandy and silty loam soil on the soil moisture content and on some characteristics of the vegetative growth and yield of radish plants. The results show that the best depth of subsurface irrigation pipes was at treatment T3 (15 cm), where the highest values of moisture content at treatment T3, and the percentage of increase of the humidity before and after irrigation when the treatment (T1, T2, T3) is (10%, 12%, 16.3%) for the silty loam soil. As for sandy soils, it is shown that the percentage increase of moisture before and after irrigation when the treatment (T1, T2, T3) is (11.6%, 16%, 22.9%); meaning that the highest increase of moisture content is at Treatment T3, and this is due to evaporation from the ground surface decreases as the depth of wet soil increases, as well as the depth of 15 cm provides a direct connection of water to the plant root area, and the results show that the best depth is for subsurface irrigation pipes 15 cm, i.e. treatment T3 in terms root weight and diameter root, plant height, leaves number, and total yield.

Keywords: Subsurface drip irrigation, sandy soil, silty loam soil, moisture content, radish

1.0 INTRODUCTION

Radish is considered one of the crops that follow the Brassicaceae family and its scientific name is Raphanus sativus L. It is called in some Arab countries Al-Ruwaid because of its leaves and roots, which are eaten fresh as the roots of some of its varieties are cooked, as in [1]. Radish belongs to the winter Crusader family, which needs a moderate temperature and tolerates low temperatures and does not tolerate high temperatures or drought.

It is also an annual crop, rapidly grown and tends to be blossomed when the day is long accompanied by high temperatures, according the bloated part of the plant is eaten, in addition to the upper part of it, as in [2]. Although the drip irrigation system is one of the most efficient systems in the water use efficiency, but the use of drippers above the soil surface causes an increase in evaporation. The need to use subsurface drip irrigation to reduce evaporation to a minimum level the matter which increases the efficiency of irrigation use. Among these systems is the use of pipes T-tape, which is a strip tube made of soft PVC materials containing openings at certain distances as in [3]. Subsurface drip irrigation can be defined as:

"Application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation " as in [4].

Among the advantages of subsurface drip irrigation is the reduction of water evaporation losses and more efficient management of nutrients and pesticides, which leads to an increase in the efficiency of irrigation water use and the quality of crops. Among the advantages are also allowing field operations even during irrigation, less infiltration, reducing the germination and growth of weeds, and reducing pests, It can save up to 25%-50 water compared to surface irrigation [5], [6] It is not necessary to install drippers at the beginning. In addition, removing them at the end of the season, and thus the possibility of using subsurface irrigation pipes for more than one season, which saves production economy as in [7]. Studies concerning ribbon tubes for radish crop is few and rare. In a study on sunflower seedlings by Salem *et al*. studying the effect of three Depths of strip irrigation (5 cm, 10 cm, and 15 cm). It was found that the best depth for the characteristics of root length and seedling height, as well as the total wet and dry weight and green weight of the plant and the root is 15 cm in [3]. In a study for Mohamed Mubarak reveals that subsurface irrigation achieved a higher moisture content , when compared with surface irrigation, the matter which led to an increase in plant height, leaf area, dry plant weight and crop growth rate, as in [8].

It also recorded less moisture loss as evaporation from the surface of the earth as in [3]. Abdel Moneim *et al*. compared two depths of strip irrigation (5 cm and 15 cm) for potato plants, the treatment of subsurface irrigation with a depth of 15 cm was significantly higher characteristics of total, relative and mineral water content, dry weight and leaf area of the plant and the soft weight of the roots [9]. Najafi also showed that tape tube irrigation is one of the ideal methods of irrigation when studying the irrigation with tape tubes above and below the soil surface on the tomato crop in depths of 15 cm and 30 cm, where the treatment under the surface land at depth is 15 cm from the rest of the treatments in terms of water consumption efficiency [10]. Najafi and Tabatabaei found that when making a comparison of surface irrigation and subsurface irrigation at depth 15 cm and 30 cm for planting two varieties of potato, and based on the results, the depth of 15 cm represents the highest efficiency of water in production, due to the improvement of soil moisture at the root zone, less infiltration of water and less evaporation from the surface [11]. Singh and Raiput said that irrigation with tape tubes is one of the ideal methods of irrigation when studying irrigation with tape tubes above and below the soil surface in depths of 5 cm, 10 cm, and 15 cm for okra yields where the increase in production was observed at 10 cm and 15 cm [7].

The current study focuses on the problems resulted from high water losses of subsurface drip irrigation systems. Moreover, we investigate the proper depth of the subsurface laterals that leads to reduce high water losses.

2.0 METHODOLOGY

This study was carried out in the educational nursery affiliated to the Department of Plant Production Technologies / Mosul Technical Institute / Northern Technical University during the agricultural season 2019-2020, to study the effect of three irrigation depths of 5 cm (T1), 10 cm (T2), and 15 cm (T3). Subsurface drip irrigation pipeline type was used heavy- walled compression resistant drip lines (hard hose) instead of the less expensive thin-walled, collapsible drip lines used in many system to solve a problem of overburden pressure [12]. By using the strip tubes that were placed at the bottom of the furrow from the side of seed cultivation, the process of preparing the field soil for planting seeds after irrigation of flooding, then plowing the soil, and then softening and leveling the soil. The experiment diagram is presented as shown in Figure 1, the seeds were planted in the field on 15/9/2019 in furrow with a distance of 0.5 m between one center and another, where the length of each furrow is 12.3 m in length and 0.5 m in width, and the area of the experimental unit was 36.9 m2. Then the strip tubes were irrigated at a rate of one irrigation process every two weeks. However, the irrigation water volume was calculated according to the daily evapotranspiration depth, as shown in Table 1

Table 1 water volume apply

Irrigation events	Daily evapotranspiration mm/day	Water volume apply (Liter)
First Irrigation 25/12/2019	1.77	979.7
The second irrigation 12/1/2020	1.4	774.9
Third Irrigation 28/1/2020	1.53	846.8
Fourth Irrigation 10/2/2020	1.57	868.9
The Fifth Irrigation 24/2/2020	2.38	1317.3
The sixth Irrigation 9/3/2020	2.92	1616.2

The experiment included two factors:
The first factor: the strip tube level at 5 cm, 10 cm and 15 cm
The second factor: sandy and silty loam soil.

The experiment was designed according to complete randomized sectors and with three replicates as in [13]. Thus, the experiment included six treatments (2 * 3). The local radish variety was used and agricultural service operations were carried out from the cultivation process until the end of the harvesting stage, as is the practice of (irrigation, weeding, hoeing the soil and removing the bushes whenever needed). The insecticide Gem was used at a rate of 0.1 ml / liter as a preventive pesticide for biting insects as well as pesticide 4 g / liter Waed to control aphids as in [14]. An irrigation control roof shed was used, which included covering the search area to prevent rain on the area and to irrigate the crop with a measured amount of water.

The studied traits: The number of plants from which measurements were taken, are eight plants / experimental unit.

1. The number of sheets,
2. Plant height: by measuring tape from the base of the plant to the end of the leaves.
3. Root weight (g)
4. Root diameter (cm)
5. Root length (cm)
6. Total production per unit area (tons / hectare)

$$\text{total production } = \frac{\text{experiment unit yield} * 2500\text{m}^2}{\text{area of experiment unit} * 1000} * 4 \qquad (1)$$

According to the following law, considering the area of a dunum is 2,500 square meters.

The soil moisture content was also calculated before and after irrigation for each irrigation to calculate the effect of the depth of strip irrigation on soil moisture. Soil moisture was measured by the gravimetric method, where the moisture was calculated by the following method:

Calculate wet weight, which is equal to W2 – W3
Calculation dry soil weight equal to W3-W1:
Then calculate the percentage of water content in the soil through the following law:

$$\text{W.C\%} = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \qquad (2)$$

Where: W1: Weight of the empty can
W2: Weight of enclosure with moist soil,
W3: Weight of the box with the soil after drying it, as in [15].

The results were analyzed statistically according to a design made by a computer using the SAS program as in [16], and the averages were compared by using the Duncan Polynomial Test at a probability level of 5 %, as in [13].

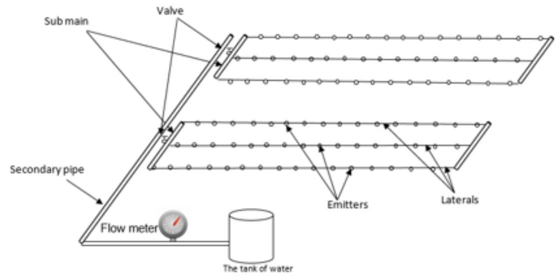


Figure 1 layout of experiment with subsurface drip irrigation system

Table 2 and Table 3, Show the physical and chemical properties of the soil of the experiment field, The method of obtaining Nitrogen extraction is summarized by the Kjeldahl method, taking a sample and digesting it with sulfuric acid. Phosphorous is a spectrophotometer and gives the number directly. Potassium via the photometer also gives a direct reading. The PH of the film device gives a direct number. The EC Tester is a direct measurement of electrical conductivity.

The texture of the soil and the amount of sand and clay is done mechanically. The organic matter is digested and disposed of, then the remaining components are placed, and by volume, the amount of sand and silt is calculated and the remaining clay is then by means of a triangle of texture, the texture of the soil is determined by color.

The results were approved by taking soil samples from the worksite and delivering them to the central laboratory in the College of Agriculture and Forestry. The work was done by people specialized in the field of soil, and we delivered the results in full.

The percentage of sand for the first and second soil reached 29.66% and 10%, clay 16.45%, 4%, silt 53.89% and 6% respectively indicating that the first soil has the silty loam and the second soil is sandy, and this result is consistent with the result obtained by a ready-made program (Soil Water Characteristics). This program has been calibrated with data and information on the two types of soil under study and the program has given reliable and good results based on brief information that includes proportions of soil components that include (sand - clay) only, and Figure 2 represents the interface of the program (Soil Water Characteristics).

Table 2 some physical and chemical characteristics of silty loam soil

Chemical characteristics		Physical characteristics	
ppm 78	Nitrogen	Silty loam	Soil tissue
19,67 ppm	Phosphor	29.66 %	sand
ppm 95,7	Potassium	16.45 %	Clay
7	PH	%53.89	silt
%59	ds/m Ec	%28.7	Field capacity (F.C.)
		%11.5	Wilting point (W.P.)

Table 3, some physical and chemical characteristics of sandy soils

Chemical characteristics		Physical characteristics	
ppm 65	Nitrogen	Sandy	Soil tissue
15,23 ppm	Phosphor	% 90	sand
ppm 82,5	Potassium	% 4	Clay
7	PH	% 6	Silt
%53	ds/m Ec	%9.3	Field capacity (F.C.)
		%4.4	Wilting point (W.P.)

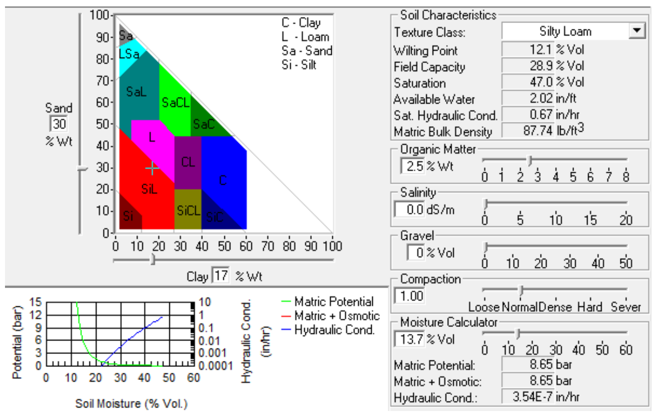


Figure 2 graphical input screen for the soil water characteristic model the shape

3.0 RESULT AND DISCUSSION

3.1 Root Weight, Root Diameter, Plant Height, and Total Yield in Different Depths

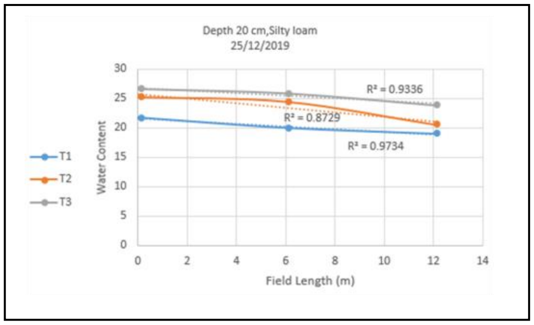
The results in Table 4, show that the cultivated plants in silty loam soils at a depth of 15 cm outperformed significantly with all characteristics and with the highest values in terms of root weight, root diameter, plant height, number of leaves and total yield, which were differed significantly with all the studied characteristics when treating silty loam at a depth of 5 cm [17], but this study was a comparison between soil depth of 5 cm, 7.5 cm and 10 cm, and the best was 10cm. Which gave the lowest values in all the studied characteristics only, the root length characteristic was superior to the 15 cm treatment, as well as the silty loam soil treatment in all the characteristics for sandy soils. Table 4, also shows that the plants cultivated in sandy soils at a depth of 15 cm were significantly superior with all the characteristics and the highest values in terms of root weight, root diameter, plant height, number of leaves and total yield, which differed significantly with all the studied characteristics when treating sandy soils at a depth of 5 cm. giving the lowest values in all the studied traits only the root length attribute surpassed the treatment of 15 cm, and this is consistent with as in [13] and [18], and this study was a comparison between soil depth of 15 cm, and 30 cm, and the best was 30 cm.

Table 4 the effect of overlap between subsurface irrigation pipe depths and soil type on the yield and quality of radish

Soil type	Depth of subsurface irrigation pipes	Root weight (g)	Root diameter (cm)	Root length (cm)	Plant height (cm)	The number of sheets	The total yield t/h
Sandy	5cm	142.22b	10.587b	11.588a	29.656b	5.554b	19.445b
	10cm	524.54ab	14.657ab	10.666a	45.644ab	15.778a	65.773a
	15cm	632.51a	16.834a	5.776b	47.744a	18.757a	80.583a
Silty loam	5cm	276.66b	12. 477b	12.635a	37.775b	8.348b	33.844b
	10cm	754.45a	19.733ab	12.644a	49.866a	24.655a	92.267a
	15cm	802.43a	20.629a	7.335c	53.553a	23.623a	101.233a

3.2 Soil Moisture Distribution in Different Depths

The soil moisture content was calculated before and after irrigation for 24 hours and for several depths at 5 cm (T1), 10 cm (T2), and 15 cm (T3) and for sixth irrigation events. Soil samples were taken from two depths of 10 cm and 20 cm and at several distances from the length of the field. (Beginning, middle and end of the field) for the two types of soil silty loam and sandy as follows: the number of soil moisture test samples was 432 sample. For the first irrigation and for the soil silty loam, and when the treatment T1 and the depth of the soil sample is 10 cm, the moisture content range before irrigation (17.64% -14.28%) and after irrigation (20.68% -17.17%), and with the same treatment T1. But at the depth of the sample 20 cm the values of the moisture content before irrigation (18.42% -15%) and after irrigation (21.73% - 19.04%), as shown in Table 5 and Figure 3, where the values of the moisture content increased 10%, which means that the soil content increases as far as soil depth increases. Because of the difference in evaporation from the soil surface, which is expected to be greater when the system is closer to the surface as mentioned in [19], but this was a comparison between soil depth of 15 cm and 30 cm, and the best was 30 cm.



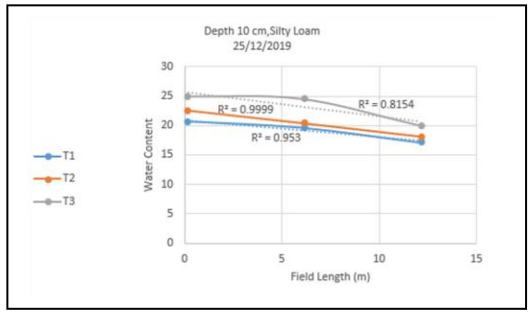


Figure 3, the values of moisture content of silty loam soils, for the treatment T1, T2, T3 and for the depth of a soil sample of 10 cm and 20 cm

Table 5 the values of moisture content before and after irrigation when treatment T1 (5 cm)

Irrigation events	Tube depth	Model taking depth	Soil type	Moisture content% Before irrigation	Moisture content% After irrigation
First Irrigation 25/12/2019	T3=5cm	10 cm	Silty loam	14.28-15.62-17.64	17.17-19.6-20.68
		20 cm	Silty loam	15-16.66-18.42	19.04-20-21.73
		10 cm	Sandy	4.5-5-5.26	5.33-7.06-8.37
		20 cm	Sandy	5-5.12-7.5	6-8.34-10.61
The second Irrigation 12/1/2020	T3=5cm	10 cm	Silty loam	11.6-14.5-16.5	17-20.66-23.21
		20 cm	Silty loam	12.1-15.23-17.94	18.18-22.23-26.78
		10 cm	Sandy	5.88-6.89-6.97	8.36-10.29-14.28
		20 cm	Sandy	6.97-8.34-9.51	9.09-10.4-15.18
Third Irrigation 28/1/2020	T3=5cm	10 cm	Silty loam	11.8-14.28-14.9	18.12-20.44-21.87
		20 cm	Silty loam	12.1-16.12-19.85	19.51-21.68-22.22
		10 cm	Sandy	4.5-8-9.09	7.14-10-13.41
		20 cm	Sandy	5-10.34-12.2	8-12.14-17.15
Fourth Irrigation 10/2/2020	T3=5cm	10 cm	Silty loam	12-16-16.6	16.1-19.5-20
		20 cm	Silty loam	13.5-19.73-20.38	16.6-21.58-22
		10 cm	Sandy	4.5-7.25-13.69	6.55-14.28-15.5
		20 cm	Sandy	5.1-9.5-13.79	7.5-15-16.34
The Fifth Irrigation 24/2/2020	T3=5cm	10 cm	Silty loam	12.2-20-21.6	16.6-22.4-23.9
		20 cm	Silty loam	16-20.8-22.8	17.7-23.5-24.6
		10 cm	Sandy	4.7-8.3-12.2	9.5-11.4-13.5
		20 cm	Sandy	6.25-11.34-12.9	10.8-13.5-17.8
The Sixth Irrigation 9/3/2020	T3=5cm	10 cm	Silty loam	13-15.7-17.6	20-23.2-25.6
		20 cm	Silty loam	14.38-17.3-18.8	21.6-23.8-26
		10 cm	Sandy	5.7-7.3-11.1	8.7-11.2-15.5
		20 cm	Sandy	6.4-7.8-12.6	10.2-11.3-17.14

The results of the treatment were T2 (10 cm), as the values of the moisture content before irrigation and at the depth of 10 cm (19.04% -15.5%) and after irrigation (22.85% - 18.14%), as for the depth of the sample 20 cm, the values of the moisture content before irrigation were (20 -16.27%) and after irrigation (25.32% -20.6%), which means that the moisture content values increased with an increase of 12% for the same previous reason as shown in Table 6, and Figure 3.

As for the treatment T3 (15 cm), the values of the moisture content were at depth of 10 cm and before irrigation (21.5% -18.51%) and after irrigation (25% - 20%), while at depth of the soil sample 20 cm and the treatment T3, the values of the moisture content were before Irrigation (22.5% -18.83%) and after irrigation (26.66% -23.91%), as shown in Table 7, and Figure 3, which means that soil moisture increased with the increase in the depth of the soil sample by 16.3%, and this is due to the decrease of evaporation as far greater the depth of the soil, and these results are similar to the results as in [20].

Table 6 the values of moisture content before and after irrigation when treatment T2 (10 cm)

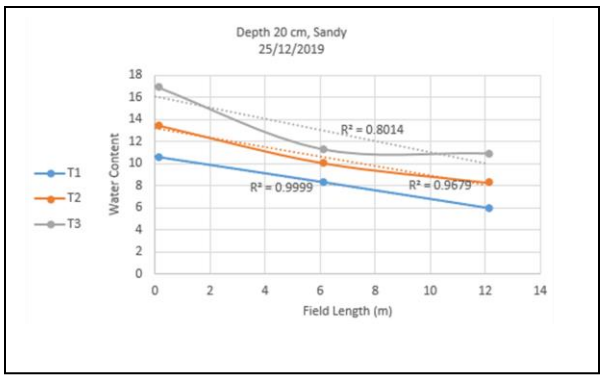
Irrigation events	Tube depth	Model taking depth	Soil type	Moisture content% Before irrigation	Moisture content% After irrigation
First Irrigation 25/12/2019	T3=10cm	10 cm	Silty loam	15.5-18.03-19.04	18.14-20.4-22.58
		20 cm	Silty loam	16.27-18.96-20	20.6-24.52-25.32
		10 cm	Sandy	5.5-6.81-7.52	7-9.52-12
		20 cm	Sandy	5.69-7.3-8	8.33-10.1-13.5
The second Irrigation 12/1/2020	T3=10cm	10 cm	Silty loam	13.2-16.05-18.18	20.4-23.52-26.9
		20 cm	Silty loam	13.88-21.95-23.07	22.5-25-27.15
		10 cm	Sandy	7.54-8.88-11.38	11.1-13.46-16
		20 cm	Sandy	8.1-10.16-12.19	12.5-14-20.45
Third Irrigation 28/1/2020	T3=10cm	10 cm	Silty loam	12.5-18.5-20	19.62-22.68-23.07
		20 cm	Silty loam	17.85-20.5-21.62	21.42-23.9-24.44
		10 cm	Sandy	5.2-11.36-15.5	8.5-13.18-17.82
		20 cm	Sandy	5.8-12.82-16.66	10-14.8-20
Fourth Irrigation 10/2/2020	T3=10cm	10 cm	Silty loam	15.6-20-20.51	18.42-21.58-24
		20 cm	Silty loam	16.5-20.5-21.1	19.76-22.58-25.8
		10 cm	Sandy	5.38-10.34-13.9	8-15.1-16.6
		20 cm	Sandy	6.52-12-15.15	9.5-15.38-16.9
The Fifth Irrigation 24/2/2020	T3=10cm	10 cm	Silty loam	16.6-22.2-23	18.6-24.2-25.5
		20 cm	Silty loam	18.8-23.8-25.14	20.3-25.9-27.4
		10 cm	Sandy	7.4-12.28-16.6	12.5-15-20
		20 cm	Sandy	10-12.5-18	14.5-16.1-20.6
The Sixth Irrigation 9/3/2020	T3=10cm	10 cm	Silty loam	15-18-19.5	22-25-26.13
		20 cm	Silty loam	16.6-19.3-20.7	24.2-26.5-27.27
		10 cm	Sandy	8.3-9.5-14.5	11.5-12-18
		20 cm	Sandy	10.5-11.11-15.6	14-16-20.5

By comparing the values of the moisture content with the depth of the subsurface irrigation pipes (T1, T2, T3), it becomes clear that the highest moisture content was at T3, that is, at 15 cm, as mentioned as in [9], and this is due to the decrease of evaporation from the ground surface as the depth of the wet soil increases as in [11]. The results of treatment T3 were better because it provides a direct connection of water to the plant root area as in [4], and the results of moisture when monitoring all irrigation processes (the second to the sixth irrigation) were identical to the results of the first irrigation, which is the increase in humidity with an increase in the depth of the soil model and the depth subsurface irrigation pipe, and these results are similar to the results as in [19].

The moisture content values are also found close to the field capacity (Field Capacity F.C. = 28.7%), i.e., they are within the specifications. The difference between the humidity levels for the three parameters (T1, T2, T3) is due to the loss of water because of evaporation as in [21]. It is also noted that there are little differences in the values of moisture content, i.e. more consistency and more regularity in the values of moisture distribution along the field when treatment T3 i.e. at 15 cm as in [7] and [4].

Table 7 values of moisture content before and after irrigation when treatment T3 (15 cm)

Irrigation events	Tube depth	Model taking depth	Soil type	Moisture content% Before irrigation	Moisture content% After irrigation
First Irrigation 25/12/2019	T3=15cm	10 cm	Silty loam	18.51-19.04-21.5	20-24.56-25
		20 cm	Silty loam	18.83-20.83-22.5	23.91-25.92-26.66
		10 cm	Sandy	7.33-9.52-12.5	8.4-10.55-14.52
		20 cm	Sandy	7.84-10.5-16.66	10.9-11.32-17
The second Irrigation 12/1/2020	T3=15cm	10 cm	Silty loam	19.44-22.5-23.83	22.55-25.24-27.27
		20 cm	Silty loam	20.04-24.13-26.15	25-25.8-28
		10 cm	Sandy	8.52-12.5-16.32	14-15.55-21.42
		20 cm	Sandy	9.09-13.95-18.86	15.8-16.5-23.33
Third Irrigation 28/1/2020	T3=15cm	10 cm	Silty loam	18.75-21.73-22.5	22.22-23.93-25
		20 cm	Silty loam	19.76-23.8-24.39	25-25.5-26.52
		10 cm	Sandy	6-13.79-17.91	10.38-16.12-20.68
		20 cm	Sandy	7-14.8-20	16-17.3-22.75
Fourth Irrigation 10/2/2020	T3=15cm	10 cm	Silty loam	17.51-20.9-21.42	21.8-24.8-26
		20 cm	Silty loam	20-21.73-22.72	24.48-25.4-27.31
		10 cm	Sandy	7.7-12.5-19.35	9.6-16.6-21.21
		20 cm	Sandy	9.53-13.15-18.93	12.25-17.24-21.38
The Fifth Irrigation 24/2/2020	T3=15cm	10 cm	Silty loam	20-24.5-25.9	21.8-26.2-27.8
		20 cm	Silty loam	21.62-25.8-26.6	24.2-27.7-29
		10 cm	Sandy	11.5-13.7-18.5	16-16.7-23
		20 cm	Sandy	12.2-14.8-22.2	19-20-25.9
The Sixth Irrigation 9/3/2020	T3=15cm	10 cm	Silty loam	17.6-20-21.5	25-28.2-29.2
		20 cm	Silty loam	18.18-21.6-22.7	28-29.1-30.4
		10 cm	Sandy	11.11-14-16.6	16-17.39-21.5
		20 cm	Sandy	13.79-16-18.18	20-21.3-22.3



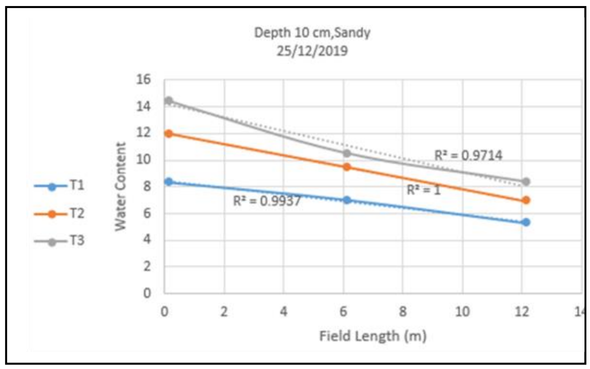


Figure 4 the values of the moisture content of sandy soils, for treatment T1, T2, T3 and for the depth of a soil sample of 10 cm and 20 cm

As for sandy soils, at the first irrigation with treatment T1 and depth of the soil sample is 10 cm, the moisture content before irrigation was (5.26% -4.5%) and after irrigation (8.37% -5.33%), and at the same treatment (T1), but the depth of the soil sample is 20 cm. The values of the moisture content ranged before irrigation (7.5% -5%) and after irrigation (10.61% -6%), i.e. and the values of the moisture content increased to 11.16%, as in Table 5, and Figure 4. This means soils moisture content increases when the soil depth increases because of the difference in evaporation from the soil surface, which is expected to be greater when the system is closer to the surface as in [7].

As for treatment T2 and at the depth of sample 10 cm, the values of the moisture content before irrigation were (7.52% -5.5%) and after irrigation (12% - 7%), and at the depth of the sample 20 cm, it was found that the values of the moisture content before irrigation were (8% -5.69%) and after irrigation (13.5% - 8.33%), as in Table 6, and Figure 4, which means that the values of moisture content increased with an increase in soil depth by 16% for the same previous reason.

As for the treatment T3, it was found that the value of the moisture content at the depth of the sample was 10 cm before irrigation (12.5%-7.33%) and after irrigation (14.52% -8.4%), and at the depth of the sample 20 cm it was found that the values of the moisture content before irrigation were (14.6% -7.84%) after irrigation (17% -10.9%) as in Table 7, and Figure 4, which means that the moisture content values increased with an increase in the depth of the soil sample to 22.9%, and this is due to the decreased of evaporation as the depth of the soil increases when comparing the value of soil moisture with the depth of pipelines. In subsurface irrigation (T1, T2, T3), it was found that the highest humidity was at T3, i.e. at 15 cm as mentioned in the current study [21]. This is due to evaporation from the soil surface, it decreases as the depth of wet soil increases as in [11], and the results of treatment T3 were better, because it provides a direct connection of water to the plant root area as in [4], and the results of monitoring the humidity of all irrigation (the second to the sixth irrigation) were identical to the results of the first irrigation, which is the increase in humidity with an increase in the depth of the soil model and the depth of the subsurface irrigation tube, and these results are similar to the results as in [7]

The moisture content values are also found close to the field capacity (Field Capacity F.C. = 9.3%), which means that they are within the specifications. In addition, the slight difference in the values of the moisture content was observed, i.e. more consistency and more regularity in the values of the moisture distribution along the field length when treatment T3 i.e. at 15 cm, as is the case in silty loam soils as in [7] and [4], it was found that the values of the moisture content of the silty loam soil are greater than the sandy soil due to the ability of the silty soil to hold more water particles than the sandy soil, and this corresponds to the response of the plant (such as the length of the root and the number of leaves).

4.0 CONCLUSION

The results of the study showed that the depth of 15 cm for subsurface drip irrigation tubes gave the highest level of humidity and uniformity of distribution for both soils in the study. Through this study, the correlation coefficient (R ^ 2) for the cases under study showed high and acceptable values in terms of statistical analysis. The results of comparing the effect of the depths of subsurface irrigation pipes on the characteristics of the used plant were clear at a depth of 15 cm for all the studied characteristics. Based on the above, the study recommends the use of subsurface irrigation pipes to a depth of 15 cm in order to obtain the highest productivity of the studied crops (sunflower, tomato, potato, and radish) in drip irrigation systems.

Acknowledgement

This study is supported by Northern Technical University, Technical Institute in Mosul. The authors fully acknowledged which makes this important research viable and effective.

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