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Effect of Subsurface Irrigation Depths on Growth and Fruiting Barhi Date Palm

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Abstract

ABSTRACT

This study was carried out on Barhi date palm grown on sandy loamy soil in a South Valley Agricultural Research Station (Toshka) at Abo-Simple, Aswan governorate, Egypt during three successive seasons of 2021, 2022 and 2023. It was conducted to evaluate the effect of subsurface irrigation depths (0.0, 80, 100 and 120 cm) on growth, yield, fruit quality and irrigation water use efficiency. Results showed that the studied growth traits and fruit quality parameters were higher under the 80 or 100 cm depth compared to 0.0 cm depth. Data indicated that all the studied properties significantly improved with increasing irrigation depth to 80 or 100 cm. No significant difference among irrigation depth 80 or 100 cm. Moreover, irrigation at a depth of 80 or 100 cm enhanced irrigation water use efficiency. Therefore, this study recommends using subsurface irrigation at 80 to 100 cm deep to irrigate date palm trees under Toshka conditions.

Key words: Subsurface irrigation, water use efficiency, date palm; Barhi and fruit quality.

Introduction

The amount of water available for irrigation is decreasing worldwide, especially in semi-arid zones where the water resources are limited; hence we need to increase the water

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use efficiency. Irrigation techniques have been studied in detail for decades and considerable progress has been achieved in understanding of water relations among soil, plant and atmosphere. However, more accurate predictions of the crop water requirement for field condition in fruit tree orchards are necessary to reduce the water consumption. Irrigation techniques have been studied in detail for decades and considerable progress has been achieved in understanding of water relations among soil, plant and atmosphere **[1]**. Crops that require less irrigation water and which are considered drought tolerant such as date palm are dominant in these regions. In date palm the root zone depth is ranging between 1.5 to 2.5 m. The tree could uptake 60 to 80% of water within a root zone depth not exceeding 1.2 m **[2]**.

Subsurface drip irrigation (SDI) is one of effective irrigation methods, but it is easy to clog **[3]**. It is the key problem of the SDI system whether emitters are clogged. These clogging were mainly caused by attached granules. To keep SDI advantages and reduce emitter clogging, a new irrigation method was suggested to irrigate date palm trees; this method is called deep sewage drip irrigation system (DSDI). The tube emitter system with laminar flow suffers more severe clogging than the labyrinth system with turbulent flow, because laminar flow is predisposed to clogging **[4]**.

A typical SDI system often requires additional components, compared to DI, such as flush lines, additional air/vacuum relief valves, and pressure gauges and a flow meter for system monitoring **[5]**.

Date palm water requirement varies with the location, climate and irrigation methods. Under surface irrigation methods, water requirement ranged from 270 to 380 m^3 per tree. The annual water requirements for a mature date palm tree range between 115 and 306 m^3 **[6]**. Date palm water requirement may reduce to less than 40 m^3 per tree with the application of subsurface drip irrigation **[7]**. Reducing water supply of date palm to 50% produced a similar yield with high quality; however, water requirement varied according to climate, tree age and location **[8]**.

The root zone of perennial trees is irregular and occupies the larger volume which may exceed the irrigated volume. So the proper monitoring of water status in orchard is

very important as the soil water content is spatially variable within an orchard **[9]**.Subsurface drip systems may help to improve the irrigation systems in orchard as they offer to deliver the water and nutrients directly to the root zone **[10]**.

The present study aimed to investigate the influence of depths of subsurface drip irrigation tubes on Barhi date palm growth and fruiting under Toshka conditions.

Material and methods

This study was carried out during three successive seasons of 2021, 2022 and 2023 in a South Valley Agricultural Research Station (Toshka), at Abo-Simple, Aswan Governorate, Egypt. Barhi date palm trees of 10 years old grown in sandy loam soil, and spaced 7x7 m. Laboratory work of this study was conducted in Pomology Department, Faculty of Agriculture, Aswan University, Egypt.

Twelve healthy female palms trees with no visual nutrient deficiency symptoms, nearly uniform in shape, size and productivity were chosen and devoted to achieving this experiment. The experiment four depths irrigation were:

T1- Surface irrigation at 0.0 cm depth (control).

T2- Subsurface irrigation at 80 cm depth.

T3- Subsurface irrigation at 100 cm depth

T4- Subsurface irrigation at 120 cm depth.

The experiment was designed as complete randomized block with three replicates for each treatment and each replicate was represented by one palm.

The experiment is the depth of irrigations a 3-inch leakage drip lines was used, and it was cut into 80 cm, 100 cm and 120 cm lengths. It was placed vertically in hole on both sides of the palm tree.

The piece was covered with a 3-inch section, and water was delivered to the plot through a spaghetti irrigation hose; at the end of which there were bubbler with a charge at 8 liters per hour per tree.

In general, the following measurements were determined during the three studied seasons.

1- Number of newly growing leaves was determined at the end of growth season. In addition, four mature leaves were chosen on each palm to determine number of pinnae/leaf and pinnae area (cm^2) as pinnae area = length x max. width x 0.84, according to **[11]**. The whole leaf area (m^2) was obtained from multiplying the pinnae area by the number of pinnae/leaf.

2- Leaf mineral content. To determine leaf mineral content (NPK), leaf samples were taken during November and washed with tap water then with distilled water to remove the dust. After washing, they were dried in an electric oven at 70°C for 72 hours. The dried leaves were ground, digested and prepared for analysis using the methods described by **[12]**.

3- Yield: All bunches were harvested at khalal stage, bunches of each palm were picked and weighed; then the yield/palm (kg) was recorded.

4- Fruit physical and chemical properties: Fifty fruits were taken at harvest date from each palm to determine some physical and chemical fruit characteristics. Physical characteristics including fruit weight and pulp percentage as well as fruit length and diameter which measured by Vernier caliper. Whereas, the chemical constituents were total soluble solids percentage by using a hand refractometer as well as sugar content (total, reducing & non-reducing) according Lane and Eynon, volumetric and total acidity as g. malic acid per 100 g pulp was determined according to procedure as outlined **[13]**. As well as, percentage of tannin in the fruits was determined using the Indigo Carmen indicators. Titration was carried out using 0.1 N potassium permanganate solutions. Tannins in fresh weight were calculated (as total tannins percentage) according to the following equation:

1 ml potassium permanganate (0.1 N) = 0.00416 g tannins according to **[14]**.

5- Irrigation water use efficiency (WUE) kg/m^3 was estimated as follow:

WUE = yield kg/ IR (m^3).

This is the ratio of crop yield to total amount of consumed irrigation water (IR) during the grown seasons.

Data were statistically analyzed and differences between treatments means were compared using L.S.D. test at 5% level according to **[15; 16]**.

Results

Data in Tables (1 & 2) showed the effect of subsurface irrigation depths on vegetative grow, i.e. new leaves number/palm/year, leaf length, leaflets area, leaf area and total chlorophyll of Barhi date palm during 2021, 2022 and 2022 seasons. It is obvious from the data that results took similar trend during the three studied seasons.

Results clearly show that the studied growth traits increased as the subsurface irrigation depths 80 or 100 cm compared to surface irrigation depth 0 cm. No significant differences between 80 or 100 cm of irrigation depth. The highest new leaves number, leaf length, total leaf area and total chlorophyll obtained due to use subsurface depth at 100 cm compared the lowest one recorded by using surface irrigation at 0.0 cm depth.

The recorded new leaves number was (18.93, 20.22, 19.95 and 19.78 leaf as an av. of the three studied seasons) due irrigate at depth of 0.0, 80, 100 and 120 cm, respectively. The corresponding total leaf area was (2.52, 2.65, 2.66 and 2.64 m^2) and total chlorophyll was (89.86, 96.37, 94.25 and 94.18 SPAD). Then, the increment percentage of New leaf attained (6.81, 5.39 & 4.49%), total leaf area (6.75, 5.56 & 4.76%) and total chlorophyll (7.24, 4.90 & 4.80%) due use 80, 100 and 120 cm compared to 0.0 cm, respectively.

Table (1): Effect of irrigation depth on some leaf traits of Barhi date palm during 2021, 2022 and 2023 seasons

	New leaves number				**Total leaf area m^2**				**Leaf length**			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	19.0 B	19.13 B	18.67 B	**18.93 B**	2.48 B	2.53 B	2.56 B	**2.52 A**	4.22 B	4.30 B	4.24 B	**4.25 B**
80 cm	20.33 A	20.33 AB	20.0 A	**20.22 A**	2.64 A	2.69 A	2.74 A	**2.69 A**	4.49 A	4.58 A	4.53 A	**4.53 A**
100 cm	19.67 AB	20.50 A	19.67 AB	**19.95 A**	2.60 A	2.66 A	2.71 A	**2.66 A**	4.42 AB	4.52 AB	4.46 AB	**4.47 A**
120 cm	19.67 AB	20.0 AB	19.67 AB	**19.78 B**	2.59 A	2.64 A	2.69 AB	**2.64 A**	4.40 AB	4.50 AB	4.43 AB	**4.44 A**

L.S.D	1.22	1.35	1.11	0.72	0.14	0.13	0.17	0.09	0.23	0.25	0.27	0.15

Table (2): Effect of irrigation depth on leaflets area; total chlorophyll and leaf nitrogen of Barhi date palm during 2021, 2022 and 2023 seasons.

	Leaflets area cm^2				Chlorophyll				Leaf-N %			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	110.8 B	116.8 B	119.8 B	**115.8 B**	85.83 B	96.36 B	93.68 B	**89.86 B**	0.98 B	1.01 B	0.98 B	0.99 **B**
80 cm	118.7 A	124.3 A	127.5 A	**123.5 A**	92.59 A	96.98 A	99.55 A	**96.37 A**	1.03 AB	1.06 AB	1.04 AB	1.04 **A**
100 cm	115.5 AB	121.5 AB	124.7 AB	**120.6 AB**	90.52 AB	94.78 AB	97.47 AB	**94.26 A**	1.05 A	1.68 A	1.05 A	1.06 **A**
120 cm	114.9 AB	121.8 AB	125.9 AB	**120.9 AB**	89.7 AB	95.18 AB	97.65 AB	**94.18 A**	0.96 B	1.00 B	0.97 B	0.98 **B**
L.S.D	**5.86**	**6.29**	**7.11**	**3.89**	**5.48**	**5.94**	**5.53**	**3.34**	**0.06**	**0.06**	**0.03**	**0.03**

Leaf-N, P and K percentage:

Data in Tables (2 & 3) showed the effect of subsurface irrigation depths on leaf-N, P and K contents of Barhi date palm during 2021, 2022 and 2022 seasons. It is obvious from the data that results took similar trend during the three studied seasons.

Results clearly show that the studied leaf-N, P and K increased as the subsurface irrigation depths 80 or 100 cm compared to surface irrigation depth 0.0 cm. No significant differences between 80 or 100 cm of irrigation depth. The highest leaf-N, P and K obtained due to use subsurface depth at 100 cm compared the lowest one recorded by using surface irrigation at 0.0 cm depth.

The recorded leaf-N % (0.99, 1.04, 1.06 and 0.98% as an av. of the three studied seasons) due irrigate at depth of 0.0, 80, 100 and 120 cm, respectively. The leaf-P % was (0.296, 0.311, 0.317 and 0.292%). The corresponding leaf-K % was (0.39, 0.41, 0.42 and 0.38%). Then, the increment percentage of leaf-N attained (5.05 & 7.07%); leaf-P (5.07 & 7.09%) and leaf-K (5.13 & 7.69%) due use 80 and 100 cm compared to 0.0 cm, respectively.

Table (3): Effect of irrigation depth on leaf-P&K contents and bunch weight of Barhi date palm during 2021, 2022 and 2023 seasons.

	Leaf-P %				Leaf-K %				Bunch weight (kg)			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	0.292 B	0.303 AB	0.294 AB	0.296 **B**	0.39 B	0.40 B	0.39 B	0.39 **B**	13.81 B	14.32 B	14.45 B	**14.19 B**
80 cm	0.308 AB	0.316 AB	0.310 AB	0.311 **A**	0.41 AB	0.41 AB	0.42 A	0.41 **AB**	14.90 A	15.32 A	15.38 AB	**15.20 A**
100cm	0.313 A	0.324 A	0.315 A	0.317 **A**	0.42 A	0.43 A	0.42 A	0.42 **A**	15.48 A	15.15 AB	15.48 A	**15.37 A**
120cm	0.289 B	0.296 B	0.290 B	0.292 **B**	0.38 B	0.39 A	0.38 B	0.38 **B**	13.36 A	13.98 B	14.51 B	**14.51 B**
L.S.D	**0.019**	**0.025**	**0.022**	**0.014**	**0.03**	**0.03**	**0.02**	**0.02**	**0.85**	**0.96**	**0.89**	**0.53**

Yield components:

Data in Tables (3 & 4) showed that the effect of subsurface irrigation depths on yield components of Barhi date palm during 2021, 2022 and 2023 seasons. It is obvious from the data that results took similar trend during the three studied seasons.

Results indicate that yield components i.e., bunch weight and yield kg/palm significantly varied due to irrigation depths used from 0 to 120 cm. It could be noticed that yield/palm and bunch weight were significantly increased with increasing irrigation depth from 0.0 to 120 cm. In this respect, the best treatment that gave the highest significant yield/palm was (205.0 & 202.8 kg) and bunch weight was (15.20 & 15.37 kg as an av. of the three studied seasons) due to use 80 or 100 cm, respectively. On other hand, the least values recorded of the palm that irrigated at the 0.0 cm at the soil surface, where it recorded (18.04 and 14.19 kg as an av. of the three studied seasons). No significant differences were found due to increase the irrigation depth used from 80 to 100 cm.

The recorded bunch weight was (14.19, 15.20, 15.37 & 14.51 kg) and yield/palm was (177.1, 209.0, 202.8 & 186.4 kg/palm as an av. of the three studied seasons) due to use 0.0, 80, 100 and 120 cm, respectively. Then the corresponding increment percentage of yield/palm due to 80 or 100 cm over 0.0 attained (15.75 & 14.51%), respectively.

Table (4): Effect of irrigation depth on Yield components and fruit weight of Barhi date

palm during 2021, 2022 and 2023 seasons

	Yield/palm (kg)				Fruit weight				Flesh %			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	169.2 B	181.9 B	180.3 B	**177.1 B**	16.21 B	16.13 B	16.29 B	**16.21 B**	88.95 B	90.16 B	89.68 B	**89.58 B**
80 cm	193.4 A	208.0 A	213.6 A	**205.0 A**	17.03 B	17.21 AB	17.38 AB	**17.21 A**	93.51 A	94.75 A	94.55 A	**94.27 A**
100 cm	196.3 A	200.9 AB	211.3 A	**202.8 A**	17.42 A	17.58 A	17.63 A	**17.54 A**	94.25 A	94.32 A	94.60 A	**94.39 A**
120 cm	178.1 B	191.2 B	191.6 B	**186.9 B**	15.65 B	15.82 B	16.02 B	**15.83 B**	68.19 B	89.97 B	89.66 B	**89.27 B**
L.S.D	**10.13**	**11.85**	**12.35**	**6.75**	**0.98**	**1.12**	**1.22**	**0.67**	**3.18**	**2.98**	**3.11**	**1.88**

Fruit quality:

A- Fruit physical characteristics:

Results in Tables (4 & 5) indicate that fruit weight, fruit length, fruit dimensions and flesh percentage were significantly affected by different irrigation depths used during three studied seasons. In general data showed positive correlation occurred between irrigation depth used and physical fruit properties. Data referred that used 80 or 100 cm of depth recorded the highest value compared to use 0.0 of irrigation. In general view, the highest values of fruit physical properties were noticed in palms irrigated at 80 or 100 cm of depth, while the lowest values were recorded in palms that irrigated at 0.0 or 120 cm. No significant differences due to increase the depths of irrigation used from 80 to 100 cm.

The recorded fruit weight was (16.21, 17.21, 17.51 & 15.83%) and flesh % (89.58, 94.27, 94.39 & 89.27%) and fruit length (3.44, 3.64, 3.71 & 3.34 cm) and fruit diameter (2.45, 2.59, 2.62 & 2.40 cm as an av. of the three studied seasons) due to irrigate with 0.0, 80, 100 and 120 cm of depths, respectively.

Moreover, the increment percentage of fruit weight attained (6.17 & 8.80%) and flesh % (5.23 & 5.36% due to use 80 or 100 cm of irrigation depth compared to use 0.0 cm of depth, respectively.

These results showed that no significant differences were seen due to increase the

irrigation depth from 80 to 100 cm.

Table (5): Effect of irrigation depth on some physical fruit properties and TSS of Barhi date palm during 2021, 2022 and 2023 seasons.

	Fruit diameter				Fruit length				T.S.S			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	2.43 B	2.46 B	2.47 B	**2.45 B**	3.42 B	3.44 B	3.46 B	**3.44 B**	45.4 B	45.9 B	45.5 B	**45.6 B**
80 cm	2.56 A	2.59 A	2.61 A	**2.59 A**	3.61 A	3.64 A	3.68 A	**3.64 A**	46.6 A	47.3 A	46.9 A	**46.9 A**
100 cm	2.61 A	2.63 A	2.63 A	**2.62 A**	3.69 A	3.71 A	3.72 A	**3.71 A**	46.9 A	47.1 AB	47.0 A	**47.0 A**
120 cm	2.38 B	2.41 B	2.42 B	**2.40 B**	3.32 B	3.36 B	3.35 B	**3.34 B**	44.9 A	45.8 B	45.6 B	**45.4 B**
L.S.D	**0.09**	**0.11**	**0.13**	**0.07**	**0.16**	**0.18**	**0.18**	**0.11**	**1.28**	**1.22**	**1.31**	**0.75**

B- Fruit chemical characteristics:

It is clear from the results in Tables (5, 6 & 7) that using 80 to 100 cm irrigation depth significantly resulted in improving fruit chemical properties, in terms of increasing TSS%, sugar contents and decreasing the acidity and tannins in relative to used 0.0 of irrigation depth.

As for TSS% and sugar contents, the results in Tables (5 & 6) reveal a descending order better results (45.6, 45.9 & 47.0) and (41.2, 42.4 & 42.4% as an av. of the three studied seasons) due to 0.0, 80 or 100 cm irrigation depth, respectively. On the other hand, using 120% scored the lowest value in this respect (45.4 & 40.8%), respectively.

Then, the corresponding increment percentage of total soluble solids attained (2.85 & 3.07%) due to 80 or 100 cm compared to 120 cm of irrigation depth, respectively.

Moreover, no significant differences were found due to increase the irrigation depth from 80 to 100 cm. Therefore, from economic view, it was concluded that irrigate should be done at a depth of 80 cm to obtain the best dates quality. With regard to acidity % and tannins contents, use 80 or 100 cm for irrigation depth reduced such studied traits as compared with used 0.0 or 120 cm of depth.

In general, the lowest percentage of fruit chemical properties except acidity and

tannins contents were found in dates from palm that irrigated with 0.0 or 120 cm of depth. On the other hand, irrigated with 80 or 100 cm recorded the highest value in this respect. No significant differences were found due to increase the irrigation depth from 80 to 100 cm. So, in general economic view, it concluded that irrigation at a depth of 80 cm is required to obtain high yield with good dates quality.

Table (6): Effect of irrigation depth on sugar contents of Barhi date palm during 2021, 2022 and 2023 seasons

	Total sugar				Reducing sugar				Non-reducing sugar			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	40.8 B	41.3 B	41.4 B	**41.2 B**	38.8 B	30.4 B	30.6 B	**30.3 B**	10.8 A	10.9 A	10.8 AB	**10.8 B**
80 cm	41.9 AB	42.6 A	42.8 A	**42.4 A**	30.8 B	31.3 B	31.7 AB	**31.2 A**	11.1 A	11.3 A	11.1 A	**11.2 A**
100cm	42.2 A	42.4 B	42.6 A	**42.4 A**	31.1 A	31.6 A	31.9 A	**31.5 A**	11.1 A	10.8 A	10.7 B	**10.9 B**
120cm	40.5 B	40.9 A	40.4 B	**40.8 B**	29.8 B	30.3 B	30.6 B	**30.2 B**	10.7 B	10.6 B	10.3 B	**10.5 C**
L.S.D	**1.32**	**1.25**	**1.29**	**0.60**	**0.98**	**1.08**	**1.05**	**0.63**	**0.39**	**0.41**	**0.36**	**0.23**

Table (7): Effect of irrigation depth on acidity, tannins and water use efficiency of Barhi date palm during 2021, 2022 and 2023 seasons.

	Acidity				Tannins				Water use efficiency kg/m^3			
Season	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**	**2021**	**2022**	**2023**	**M**
0.0 cm	0.122 AB	0.118 AB	0.125 A	**0.122 A**	0.213 AB	0.205 A	0.219 A	**0.212 A**	2.62 B	2.82 B	2.80 B	**2.75 B**
80 cm	0.117 B	0.115 B	0.120 B	**0.117 B**	0.203 B	0.195 B	0.208 B	**0.202 B**	2.99 AB	3.22 A	3.31 A	**3.18 A**
100cm	0.116 B	0.115 B	0.118 B	**0.116 B**	0.201 B	0.191 B	0.206 B	**0.199 B**	3.04 A	3.11 AB	3.28 A	**3.14 A**
120cm	0.124 A	0.121 A	0.127 A	**0.124 A**	0.215 A	0.207 A	0.220 A	**0.214 A**	2.76 B	2.96 AB	2.97 AB	**2.90 B**
L.S.D	**0.006**	**0.005**	**0.006**	**0.004**	**0.01**	**0.009**	**0.011**	**0.006**	**0.27**	**0.31**	**0.29**	**0.17**

Irrigation water use efficiency (IWUE)

Recorded data in (Table 7) proved that, irrigated at depth 80 or 100 cm gave the highest values compared to use 0.0 or 120 cm of depth. The recorded value of I. W.U.E. for date palm fruits were 2.75, 3.18, 3.14 and 2.90 kg m^{-3}, respectively, under irrigation depth of 0.0, 80, 100 and 120 cm. Hence, the increment percentage of water use efficiency attained (15.64 & 14.18%) due to use deep irrigation 80 and 100 cm compared to surface irrigation of the soil. Hence, it can be reduced the amount used water of surface irrigation to 85% to give itself surface irrigation water efficiency. In other words, improvement of I.W.U.E. may be attributed with available water formed in the root zone, but not the amount of applied water. These results may be attributed to the effects of deep drip irrigation which led to increased moisture with decreased water consumption. These results were similar to those reported **[8, 17]**

DISCUSSION

Date palm is a large tree and its water requirements are comparatively high. Reservation and maximization of water use efficiency in arid and semi-arid regions through modern irrigation technologies has become a key for sustainable crop production **[2]**

All previous mentioned growth parameters of date palm tended to increase by increasing the subsurface deep to 80 or 100 cm. Thus, it can be concluded that, the active photosynthesis net assimilation relative growth rates affected by the soil moisture distribution **[18]**.Subsurface drip irrigation system provided the crop with adequate water requirement at the root zone due to their high performance and efficiency. An additional possible explanation of these results is that drip irrigation offers better distribution of water in the soil. As a result, the root volume wetted beneath the surface is larger due to lateral movement of water, and the slow application and redistribution of soil water provide better soil aeration. The result agrees with the result obtained **[8, 17, 19]**

The soil moisture distribution before irrigation was almost a straight line, indicating that the depletion of water was from both the horizontal and vertical directions. Such results could be due to presence of the active wide deep roots of date palm. The distribution of roots along the depth is highly dependent on soil texture. The soil of the experimental site is an uncompact sandy loam which might allow a strong active root zone with a large

number of thick roots that enable the trees to take water from all directions **[20]** .With use subsurface irrigation depth about 80 or 100 cm, moisture distribution moves in the vertical direction more than the horizontal direction. However, under surface irrigation at 0.0 cm deep, moisture distribution moves in the vertical direction. Moving water in the vertical and horizontal directions is controlled by infiltration rate and discharge. On the other hand, when infiltration rate is higher than discharge, movement in the vertical direction is dominant **[21].**When the infiltration rate is decreased, movement of water in the horizontal direction is increased. The change in moisture content distribution revealed that all supplied water was retained in the upper 40 cm layer of soil depth and increased with increasing water regimes. The results might be partially related to the deep roots because they play an important role especially under water-stress conditions **[22]**

CONCLUSION

The results for the study showed that, all the studied properties significantly affected with increasing subsurface depth to 80 or 100 cm. Thus, this study recommends using subsurface irrigation at 80 to 100 cm to improve water use efficiency and get high yield with good quality of Barhi date palm trees under Toshka, Abo-Simple, Aswan conditions.

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تأثير أعماق الري تحت السطحي علي نمو وإثمار نخيل البلح البرحي

الملخص العربي

أجريت هذه الدراسة خلال مواسم 2021 حتي 2023 بالمزرعة البحثية الخاصة بمحطة بحوث جنوب الوادي – توشكا – أبو سمبل – أسوان – مصر، بهدف دراسة تأثير أعماق الري تحت السطحي علي كفاءة استخدام الماء ونمو وإثمار نخيل البلح البرحي، حيث تم استخدام ثلاثة أعماق للري تحت السطحي (80 ، 100 ، 120 سم) مقارنة باستخدام الري السطحي.

وقد أظهرت النتائج التالي:

- حدث زيادة تدريجية في صفات النمو الخضري والمحصول نتيجة الري تحت السطحي بعمق 80 أو 100 سم مقارنة بالري السطحي.
- لم تسجل فروق معنوية نتيجة زيادة عمق الري من 80 إلي 100 سم.
- سجلت أفضل صفات ثمرية عند استخدام الري تحت السطحي علي أعماق 80 أو 100 سم مقارنة بالري السطحي أو تحت السطحي بعمق 120 سم.
- سجلت أعلي كفاءة لاستخدام ماء الري نتيجة الري تحت السطحي بعمق 80 أو 100 سم.

من نتائج هذه الدراسة فإنه يمكن استخدام الري تحت السطحي بعمق 80 إلي 100 سم ذلك لزيادة كفاءة استخدام ماء الري مع إنتاج محصول عال ذو خصائص ثمرية جيدة لنخيل البلح البرحي تحت ظروف توشكا- أبو سمبل – أسوان.