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A COMPARATIVE STUDY OF TRADITIONAL AND MODERN IRRIGATION SYSTEMS MANAGEMENT FOR IRRIGATING DATE PALM TREES IN NEWLY RECLAIMED LANDS

[144]

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ABSTRACT

A field experiment was conducted in newly reclaimed sand soil to find out the most efficient combination between irrigation system and deficit irrigation management can be used for date palm trees "*Zaghlol cultivar".* Results revealed that the average water requirements of date palm trees gradually increased from 1504, 1279, 1128 and 978 for drip to 2522, 2143, 1891, and 1639 m^3/fed-Season for bubbler irrigation system in combination with 100, 85, 75 and 65% deficit irrigation treatments respectively. Data indicated that EC1:5 in dS/m gradually increased with decreasing deficit irrigation levels from 100 to 65% and with increasing soil layer depth to 60-90 cm either in parallel or perpendicular direction of drip or bubbler irrigation lines. While opposite result was observed for soil moisture distribution. Results showed an evident decrease in crop yield as affected by water stress associated with decreasing deficit irrigation treatments from 100 to 85, 75 and 65 % by about 167, 155, 153, 151 for drip and 181.5, 168, 172 and 169 kg/Tree for bubbler irrigation systems. Data revealed that water use efficiency increased from 0.10 for 100 % DI to 0.93, 0.83 and 0.64 m^3/kg for 85, 75 and 65 % deficit irrigation under drip and slightly decreased from 0.16 for 100 % DI to 0.14, 0.12 and 0.11 m^3/kg for bubbler irrigation systems respectively. It could be concluded that the best method for managing irrigation of date palm trees "Zaghloul cultivar" in the study area is the irrigation using bubbler system with 75% deficit irrigation treatment. This combination treatment gave acceptable yield of about 172 kg/tree with saving a substantial amount of Irrigation water reached to about 25% (1891 m^3/fed or 22 m^3/tree) with WUE of about 8.09 kg/m^3.

INTRODUCTION

Water shortage is an increasingly important issue in arid Arab regions where restricted supply of good quality water is the most important factor limiting crop production. The farmers in these regions had yet used unconventional techniques to increase water resources to overcome this problem. Therefore Irrigation management shifted from emphasizing production per unit area towards maximizing the production per unit of water consumed (**Fereres and Soriano, 2007**).

High efficiency micro irrigation methods, such as drip and bubbler irrigation are now in practice, which save the water and improved water use efficiency mainly by reducing runoff, growth of uneconomic weeds and evapotranspiration losses and produce high yields (**Bhattarai et al 2008; Dagdelen et al 2009 and Hull, 1981**). In this case, water use efficiency needs to be improved in this region by searching for different water management strategies such as using modern irrigation systems and sustained deficit irrigation.

The main objective of this study conducted in a field experiment, is to evaluate the rresponsse of date palm trees grown on sandy soil under arid conditions to deficit irrigation under modern irrigation systms and find out the most efficient combination treatment.

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MATERIALS AND METHODS

To achieve the main objective of this work, a field experiment was conducted on sandy soil in new reclaimed area of Oct 6Th farm in elqassasin, Ismaelia Gov., about 70 km north east of cairo using 12 years old fruiting date palm trees "Zaghloul cultivar" in about 86 trees per feddan. The irrigation system in the experimental area has been developed to allow irrigation of the tested date palm trees using bubbler irrigation beside the drip systems currently used. The experimental area was divided into eight experimental plots with 48 date palm trees for each plot.

This experiment included four sustained deficit irrigation treatments, i.e. 100, 85, 75 and 65% in combination with two modern surface irrigation systems, i.e. drip (5 drippers, 'GR-Turbo type' of 8 L/hr per tree) and bubbler (one micro sprinkler irrigation bubbler "Rain Bird type" of 60 l/hr per tree). Crop water requirements were estimated using climate method as described by Penman in Vol. 24, FAO Publication.

Each experimental plot included 4 irrigation lines of 16 mm used to irrigate 48 date palm trees. Soil samples were monthly collected from 0-30, 30-60 and 60-90 cm depth at 30, 60 and 90 cm far from the tree in two side directions, in parallel and perpendicular on the irrigation lines.

Water requirements and crop yield (harvested at mid of Sept) were determined and used for calculating water use efficiency by date palms in each treatment. This experimental was designed in complete randomizes blocks.

RESULTS AND DISCUSSIONS

Water requirements and irrigation management

Data in **Table (1)** revealed that the average water requirements of date palm trees gradually decreased with decreasing deficit irrigation from 100 to 85, 75 and 65 %, the values were 2522, 2143, 1891, and 1639 m^3/fed-Season for bubbler and 1504, 1279, 1128 and 978 m^3/fed-Season for drip irrigation system respectively. The trend of these results is in agreement with **Giordano and Filippi (1993)** who recorded some differences in date palms water requirement according the climate and locations differences, it was ranged between 1500 to 3500 mm in Algeria; about 2230 mm in Egypt and from 2500 to 3200 mm in Iraq. As expected, the average water saving were about 40% with using drip comparing to bubbler irrigation system under different deficit irrigation levels.

Depending on data of water requirements shown in **Table (1)**, the following polynomial equations were adjusted for estimating the monthly WR of date palm trees irrigated by drip or bubbler irrigation systems respectively in m^3/tree-month as a function of month factors (M) under different deficit irrigation treatments (DI) using least square procedure. However, the mathematical equation describing the WR_d (for drip) or WR_b (for bubbler irrigation system) as function of both M_{1-12} and DI_{100-65} including coefficients of determination (R^2), intercepts (S_o), and regression coefficients (S_{1-6}) for each equation could be derived in the following steps:

Step (1): WR_d or WR_b = f (M)

Finding the mathematical models describing WR as function of M_{1-12} for each DI treatment as follow:

DI	$WR = S_6 \times M^6 + S_5 \times M^5 - S_4 \times M^4 + S_3 \times M^3 - S_2 \times M^2 + S_1 \times M - S_o$	R^2
100	$WR_d = -0.0003208*M^6 + 0.01218*M^5 -0.171*M^4 + 1.0792*M^3 -3.025*M^2 + 3.77*M -1.26$	0.99
85	$WR_d = -0.00027268*M^6+0.010353*M5-0.14535*M^4+0.91732*M^3-2.57125*M^2+3.2045*M-1.071$	0.99
75	$WR_d = -0.0002406*M^6 + 0.009135*M^5 -0.12825*M^4 + 0.8094*M^3 -2.26875*M^2 + 2.8275*M -0.945$	0.99
65	$WR_d = -0.00020852*M6+0.007917*M^5-0.11115*M^4+0.70148*M^3-1.96625*M^2+2.4505*M -0.819$	0.99

Table 1. Monthly water requirements (WR) for date palm trees irrigated by drip, and bubbler systems in combination with different deficit irrigation treatments.

Month	Bubbler - deficit irrigation - % ET_c				Drip - deficit irrigation - % ET_c			
	100 %	**85 %**	**75 %**	**65 %**	**100 %**	**85 %**	**75 %**	**65 %**
	WR in m^3/fed-month under deficit irrigation treatments in %							
Jan	69.3	58.9	52.0	45.1	41.4	35.1	31.0	26.9
Feb	70.4	59.9	52.8	45.8	42.0	35.7	31.5	27.3
Mar	130.3	110.7	97.7	84.7	77.7	66.0	58.3	50.5
Apr	250.9	213.3	188.2	163.1	149.7	127.2	112.3	97.3
May	430.6	366.0	322.9	279.9	256.8	218.3	192.6	167.0
Jun	493.9	419.8	370.4	321.1	294.6	250.4	221.0	191.5
Jul	477.5	405.8	358.1	310.4	284.8	242.1	213.6	185.1
Aug	324.1	275.5	243.1	210.7	193.3	164.3	145.0	125.7
Sept	140.2	119.2	105.1	91.1	83.6	71.1	62.7	54.4
Oct	59.2	50.3	44.4	38.5	35.3	30.0	26.5	23.0
Nov	40.5	34.5	30.4	26.3	24.2	20.6	18.1	15.7
Dec	34.7	29.5	26.0	22.5	20.7	17.6	15.5	13.4
Total	**2522**	**2143**	**1891**	**1639**	**1504**	**1279**	**1128**	**978**
%	**100**	**85.0**	**75.0**	**65.0**	**59.6**	**50.7**	**44.7**	**38.8**

100	$WR_b = -0.0005*M^6 +0.0190008*M^5 -0.26676*M^4 + 1.683552*M^3 -4.719*M^2 + 5.8812*M -1.9656$	0.99
85	$WR_b = -0.00043*M^6+0.01615*M^5-0.222675*M^4+1.4310*M^3-4.01115*M^2+4.99902*M-1.67076$	0.99
75	$WR_b = -0.000375336*M^6+0.0142506*M^5-0.20007*M^4+1.262664*M^3-3.53925*M^2+4.4109*M-1.4742$	0.99
65	$WR_b = -0.0003252912*M^6+0.01235052*M^5-0.173394*M^4+1.0943088*M^3-3.06735*M^2+3.82278*M-1.27764$	0.99

Step (2): Equations indices (S) = f (DI)

Finding the mathematical models describing the above mentioned equations indices (S_{0-6}) each as a function of deficit irrigation (DI) levels using least square procedure (**Moore and McCabe 2003)** as follow:

The indices of the function of WR_d = f (M), i.e. S_{do}, S_{b1}, S_{d2}, S_{d3}, S_{d4}, S_{d5} and S_{d6} are:

DI	S_{do}	S_{d1}	S_{d2}	S_{d3}	S_{d4}	S_{d5}	S_{d6}
100	-0.0003208	0.012180	-0.17100	1.07920	-3.02500	3.7700	-1.260
85	-0.0002727	0.010353	-0.14535	0.91732	-2.57125	3.2045	-1.071
75	-0.0002406	0.009135	-0.12825	0.80940	-2.26875	2.8275	-0.945
65	-0.0002085	0.007917	-0.11115	0.70148	-1.96625	2.4505	-0.819

The mathematical models describing the above mentioned WR_d equations indices (S_{0-6}) each as a function of deficit irrigation (DI) levels using least square procedure are shown in the follow:

$S_{d6} = -0.00000009639*DI + 3E-18$ $R^2 = 1$
$S_{d5} = 0.0000063*DI + 8E-17$ $R^2 = 1$
$S_{d4} = -0.0001117*DI + 7E-16$ $R^2 = 1$
$S_{d3} = 0.00069363*DI + 5E-15$ $R^2 = 1$
$S_{d2} = -0.001642*DI$ $R^2 = 1$
$S_{d1} = 0.0064576*DI$ $R^2 = 1$
$S_{do} = -0.0009*DI$ $R^2 = 1$

The indices of the function of WR_b=f(M),i.e. S_{bo}, S_{b1}, S_{b2}, S_{b3}, S_{b4}, S_{b5} and S_{b6} are:

DI	S_{bo}	S_{b1}	S_{b2}	S_{b3}	S_{b4}	S_{b5}	S_{b6}
100	-0.0005000	0.0190000	-0.266760	1.6835500	-4.71900	5.88120	-1.96560
85	-0.0004300	0.0161500	-0.226750	1.4310200	-4.01115	4.99902	-1.67076
75	-0.0003753	0.0142506	-0.200070	1.2626640	-3.53925	4.41090	-1.47420
65	-0.0003253	0.01235052	-0.173394	1.0943088	-3.06735	3.82278	-1.27764

The mathematical models describing the above mentioned WR_b equations indices (S_{0-6}) each as a function of deficit irrigation (DI) levels using least square procedure are shown in the follow:

S_{b6} = -5E-06*DI	$R^2 = 1$
S_{b5} = 0.00019*DI - 8E-17	$R^2 = 1$
S_{b4} = -0.002669654*DI - 1E-15	$R^2 = 1$
S_{b3} = 0.0168*DI	$R^2 = 1$
S_{b2} = -0.0464*DI	$R^2 = 1$
S_{b1} = 0.057*DI + 2E-14	$R^2 = 1$
S_{bo} = -0.019*DI + 2E-14	$R^2 = 1$

Step (3): WR_d or WR_b = f (M, DI)

Water requirements of date palm trees irrigated by drip (WR_d) or bubbler (WR_b) system in m^3/tree-month as a function of both month factors and deficit irrigation levels could be mathematically described by substitute the values of the abovementioned indices (S_o, S_1, S_2, S_3, S_4, S_5 and S_6) in the function of WR = f (M), for WR_d and WR_b as follow:

$WR = S_6 \times M^6 + S_5 \times M^5 - S_4 \times M^4 + S_3 \times M^3 - S_2 \times M^2 + S_1 \times M - S_o$

WR_d= (-0.00000009639*DI + 3E-18) * M^6 + (0.0000063*DI + 8E-17) * M^5 + (-0.0001117 *DI + 7E-16) * M^4 + (0.00069363*DI + 5E-15) * M^3 + (-0.001642*DI) * M^2 + (0.0064576 *DI) * M + (-0.0009*DI).

$R^2 = 0.865$

WR_b= (-5E-06x) * M^6 + (0.00019*DI - 8E-17) * M^5 + (-0.002669654*DI - 1E-15) * M^4 + (0.0168*DI) * M^3 + (-0.0464*DI)* M^2 + (0.057*DI + 2E-14) * M + (-0.019*DI + 2E-14).

$R^2 = 0.885$

Soil salinity and moisture distribution and irrigation management

Results presented in **Tables (2 and 3)** indicated that the values of soil salinity (EC1:5 in dS/m) decreased with increasing soil layer depth to 60-90 cm under date palm trees either in parallel or perpendicular direction of drip **(Table 2)** or bubbler irrigation lines **(Table 3)**. The observed relative decreases in EC1:5 values were 69.5 and 72.4 % for drip and 59.5 and 69.2 % for bubbler in parallel and perpendicular direction from irrigation lines respectively. However the EC1:5 values increased in all soil samples collected from the perpendicular comparing with that of parallel direction under date palm trees irrigated by drip or bubbler irrigation system. This increase was not significant between drip and bubbler irrigation system. The increases in EC1:5 values of perpendicular direction were about 138 for drip (Table 2) and 145 % for bubbler irrigation system (Table 3) relative to 100 for parallel direction. These results was not expected but may be ascribed to the installation of bubbler instead of drip irrigation system that currently used in the experimental area since about 10 years ago.

Concerning the effects of soil water stress associated with the lower levels of deficit irrigation on salt distribution under date palm trees. Data in **Table (2)** indicated that EC1:5 values markedly increased with decreasing deficit irrigation levels from 100 to 85, 75 and 65 % for date palm trees irrigated by drip or bubbler irrigation systems. These increases were about 131, 199 and 360 % using drip (Table 2) and 121, 181 and 181 % using bubbler irrigation system **(Table 3)** for 85, 75 and 65 % relative to that of 100 % deficit irrigation respectively.

It could be also observed high salt accumulation in the surface soil layers of all the tested soil profiles. This result was more evident under the highest soil water stress conditions associated with decreasing deficit irrigation to 65% blow full irrigation level (100 %).

These results are in agreement with that observed by **Fereres and Soriano (2007)** who found that besides yield reduction due to deficit irrigation in some crop species, the other consequence of deficit irrigation is the greater risk of increased soil salinity due to reduced leaching and its impact on the sustainability of irrigation.

The obtained results showed that there is no clear difference between the values of EC1:5 in root growth medium of date palm trees either irrigated by drip or bubbler irrigation systems. The average values of EC1:5 were about 0.83 for drip

Table 2. Distribution of soil salinity (EC1:5 in ds/m) under date palm trees irrigated by drip system in combination with different deficit irrigation treatments

Soil depth cm	Parallel with the irrigation lines					Perpendicular on the irrigation lines				
	Deficit irrigation (%)				Mean	Deficit irrigation (%)				Mean
	100	85	75	65	dS/m	100	85	75	65	dS/m
30 cm from tree trunk										
0-30	0.40	0.40	0.30	0.50	0.40	0.40	0.40	0.40	2.60	0.90
30-60	0.30	0.3	0.31	0.40	0.33	0.30	0.40	0.30	1.90	0.70
60-90	0.23	0.28	0.27	0.29	0.26	0.25	0.37	0.30	1.70	0.60
60 cm from tree trunk										
0-30	0.40	1.00	0.40	1.60	0.80	0.90	1.00	1.70	1.00	1.10
30-60	0.42	0.84	0.41	1.26	0.73	0.80	0.82	1.55	0.78	0.98
60-90	0.36	0.75	0.37	1.02	0.63	0.60	0.62	1.25	0.65	0.78
90 cm from tree trunk										
0-30	0.25	0.25	1.44	3.00	1.23	0.71	0.70	1.51	2.32	1.31
30-60	0.24	0.24	1.28	2.48	1.06	0.57	0.67	1.31	2.09	1.16
60-90	0.17	0.22	0.92	2.00	0.83	0.51	0.56	1.11	1.96	1.04
Mean	**0.30**	**0.48**	**0.64**	**1.38**	**0.70**	**0.55**	**0.62**	**1.04**	**1.66**	**0.97**
%	**100**	**161**	**215**	**462**	**100**	**183**	**208**	**348**	**556**	**138**

Deficit irrigation (%)				Mean
100	85	75	65	EC1:5
0.42	0.55	0.84	1.52	0.83
Relative values of EC1:5				
100	131	199	360	197

Soil depth	Parallel		Perpendicular	
cm	EC1:5	%	EC1:5	%
0-30	0.82	100	1.13	100
30-60	0.71	85.9	0.96	85.0
60-90	0.57	69.5	0.82	72.4

Table 3. Distribution of soil salinity (EC1:5 in ds/m) under date palm trees irrigated by bubbler system with different deficit irrigation treatments

Soil depth cm	Parallel with the irrigation lines					Perpendicular on the irrigation lines				
	Deficit irrigation (%)				Mean	Deficit irrigation (%)				Mean
	100	85	75	65	dS/m	100	85	75	65	dS/m
30 cm from tree trunk										
0-30	0.34	0.77	0.52	0.41	0.51	0.37	0.40	0.26	1.19	0.55
30-60	0.29	0.57	0.42	0.31	0.40	0.31	0.27	0.23	0.92	0.43
60-90	0.25	0.38	0.28	0.27	0.30	0.25	0.22	0.20	0.76	0.36
60 cm from tree trunk										
0-30	0.90	1.06	1.11	1.42	1.12	1.00	0.73	1.63	2.45	1.45
30-60	0.79	0.64	0.86	1.28	0.89	0.74	0.56	1.30	1.95	1.13
60-90	0.43	0.52	0.75	0.98	0.67	0.64	0.46	1.07	1.53	0.93
90 cm from tree trunk										
0-30	0.84	0.58	0.89	1.77	1.02	1.22	1.95	1.44	2.00	1.65
30-60	0.73	0.50	0.73	1.32	0.82	1.26	1.81	1.27	1.39	1.43
60-90	0.65	0.43	0.62	0.76	0.61	1.14	1.48	1.13	1.24	1.25
Mean	**0.58**	**0.61**	**0.69**	**0.95**	**0.70**	**0.77**	**0.88**	**0.95**	**1.49**	**1.02**
%	**100**	**105**	**118**	**163**	**100**	**133**	**151**	**164**	**257**	**145**

Deficit irrigation (%)				Mean
100	85	75	65	EC1:5
0.67	0.74	0.82	1.22	0.86
Relative values of EC1:5				
100	110	121	181	128

Soil depth	Parallel		Perpendicular	
cm	EC1:5	%	EC1:5	%
0-30	0.88	100	1.22	100
30-60	0.70	79.5	1.00	81.9
60-90	0.53	59.5	0.84	69.2

and 0.86 dS/m for bubbler irrigation system. These results was not expected but may be also attributed to the installation of bubbler instead of drip irrigation system that currently used in the experimental area since about 10 years ago.

From data in **Tables (2 and 3)**, it could be concluded that the average values of EC1:5 markedly increased with decreasing deficit irrigation levels from 100 to 65 % deficit irrigation system. The relative increases were about 100, 118, 151 and 250 % for 100, 85, 75 and 65 % deficit irrigation levels respectively.

Regarding soil moisture distribution as affected by different irrigation systems (drip and bubbler) in combination with water stress conditions associated with the lower levels of deficit irrigation treatments. Results indicated a gradual reduction in soil moisture contents with increasing soil layer depth to 60-90 cm under date palm trees for both parallel or perpendicular direction of drip **(Table 4)** or bubbler irrigation lines (Table 5). The relative decreases in soil moisture contents (SMC) in sub surface soil layers, i.e. 30-60 and 60-90 cm under drip irrigation system were 82.4 and 69.2 % in parallel, 88.1 and 75.2 % in perpendicular direction from irrigation lines respectively **(Table 4)**. Similar reduction trend in soil moisture contents were also observed under bubbler irrigation system **(Table 5)**. The values of SMC under date palm trees were more pronounced for bubbler than drip irrigation systems. These results reflect the high amount of irrigation water used for date palm trees during growth season using bubbler comparing to drip irrigation system as previously shown in **Table (1)**.

It is worthy to mention that SMC values were not substantially affected by irrigation of date palm using drip or bubbler irrigation systems each alone or in combination with different deficit irrigation treatments. However, by decreasing deficit irrigation treatments from 85 to 75 or 65% the obtained relative values of SMC were 81, 78 and 85 % for drip (Table 4) and 100, 75, 72 and 74 % for bubbler irrigation system (Table 5) respectively.

Crop yield and water use efficiency and irrigation management

Data in **Table (6)** showed the date crop yield and water use efficiency by date palm trees as affected by drip and bubbler irrigation systems in combination with four deficit irrigation treatments. The average date crop yields were about 156.4 and 172.6 kg/tree or 13.4 and 15.4 ton/fed under drip and bubble irrigation systems respectively.

The relative increase in date crop yield was about 110.4 for bubbler relative to 100 for drip irrigation system. Unfortunately, the increase in crop yield in response to irrigation with bubbler system associated with a marked decrease in water use efficiency by about 34 %.

Concerning the response of date crop yield of palm trees to the different deficit irrigation treatments under investigation. Data in **Table (6)** showed an evident decrease in crop yield as affected by water stress associated with decreasing deficit irrigation treatments from 100 to 85, 75 and 65 % by about 167, 155, 153, 151 for drip and 181.5, 168, 172 and 169 kg/tree for bubbler irrigation systems. The corresponding relative decreases were about 92.8, 91.6 and 90.1 for drip and 92.6, 94.8 and 93.1 % for bubbler irrigation systems respectively relative to full irrigation treatment equal 100%.

Regarding, water use efficiency (WUE) by date palm trees as affected by the different deficit irrigation (DI) treatments. Data in Table (6) revealed that WUF in kg of crop yield per m^3 of irrigation water increased from 9.55 for 100% DI to 10.4, 11.7 and 13.2 for 85, 75 and 65 % DI for drip and from 6.19 to 6.74, 7.82 and 8.87 for bubbler irrigation systems respectively. These results are in agreement with **Kirda, (2002)** who declared that the purpose of deficit irrigation strategy is to increase crop water use efficiency (WUE) by reducing the amount of water applied, also he suggested that the reduction in yield may be small; relative to the benefit gained by saving much water can be used for irrigating other crops. Definitely, similar trend was also observed for crop yield and water use efficiency as affected by different irrigation system alone or in combination with different deficit irrigation treatments.

From the above mentioned results, it could be concluded that the best method for managing irrigation of date palm trees "Zaghloul cultivar" in the study area is irrigation using bubbler system with 75% sustained deficit irrigation. This combination treatment gave an acceptable yield about 172 kg/tree using about 1891 m^3 irrigation water per feddan or 22 m^3/tree and saving a substantial amount of irrigation water reached to about 25 % leading to an encouraging value of water use efficiency by date palm trees about 8.09 kg/m^3.

Table 4. Distribution of soil moisture content (SMC-%) under date palm trees irrigated by drip irrigation in combination with different deficit irrigation treatments

Soil depth cm	Average values of SMC in % for bubbler irrigation system									
	Parallel with the irrigation lines					Perpendicular on the irrigation lines				
	Deficit irrigation (%)				Mean	Deficit irrigation (%)				Mean
	100	85	75	65	%	100	85	75	65	%
30 cm from tree trunk										
0-30	13.8	12.2	13.7	13.3	13.3	14.6	12.0	12.0	14.0	13.1
30-60	10.3	10.0	11.5	10.9	10.7	12.8	10.4	11.5	12.1	11.7
60-90	8.54	7.73	10.0	8.99	8.82	9.32	9.52	9.4	10.1	9.6
60 cm from tree trunk										
0-30	10.6	8.4	7.9	10.5	9.4	13.6	8.64	8.1	8.6	9.7
30-60	9.23	7.80	6.94	8.86	8.21	12.4	8.19	7.14	6.80	8.63
60-90	8.15	6.55	6.30	8.25	7.31	11.0	7.57	6.10	6.42	7.78
90 cm from tree trunk										
0-30	6.49	4.81	4.04	4.80	5.03	5.25	4.44	3.31	3.70	4.18
30-60	5.03	4.20	2.79	3.54	3.89	4.20	4.05	2.83	2.90	3.50
60-90	4.06	2.91	2.33	2.74	3.01	4.03	2.96	2.14	2.86	3.00
Mean	**8.48**	**7.18**	**7.28**	**7.98**	**7.73**	**9.68**	**7.53**	**6.95**	**7.50**	**7.92**
%	**100**	**85**	**86**	**94**	**100**	**114**	**89**	**82**	**88**	**102**

Deficit irrigation (%)				Mean
100	85	75	65	SMC
9.08	7.36	7.12	7.74	7.82
Relative values of SMC				
100	81	78	85	86

Soil depth cm	Parallel		Perpendicular	
	SMC	%	SMC	%
0-30	9.22	100	9.02	100
30-60	7.42	81.1	7.90	84.5
60-90	6.38	69.2	6.78	75.2

Table 5. Distribution of soil moisture content (SMC-%) under date palm trees irrigated by bubbler irrigation in combination with different deficit irrigation treatments

Soil depth cm	Average values of SMC in % for bubbler irrigation system									
	Parallel with the irrigation lines					Perpendicular on the irrigation lines				
	Deficit irrigation (%)				Mean	Deficit irrigation (%)				Mean
	100	85	75	65	%	100	85	75	65	%
30 cm from tree trunk										
0-30	16.4	10.0	9.4	11.0	11.71	16.3	11.7	11.9	10.4	12.58
30-60	13.6	8.4	7.9	8.9	9.73	14.7	9.91	9.09	8.38	10.51
60-90	11.4	6.3	6.3	8.0	7.99	12.7	8.62	7.82	7.36	9.12
60 cm from tree trunk										
0-30	13.4	9.5	9.5	9.9	10.59	10.8	10.3	10.6	9.93	10.43
30-60	11.8	7.7	8.0	7.9	8.84	8.0	8.99	9.02	9.02	8.77
60-90	9.8	5.5	6.7	6.8	7.19	7.6	8.33	7.77	7.86	7.90
90 cm from tree trunk										
0-30	7.75	4.25	3.57	5.02	5.15	4.05	5.81	4.95	5.36	5.04
30-60	5.26	3.40	2.98	3.17	3.70	3.77	5.39	4.03	4.49	4.42
60-90	5.10	3.27	2.50	2.48	3.34	2.74	4.14	3.25	3.64	3.44
Mean	**10.5**	**6.48**	**6.32**	**7.01**	**7.58**	**8.96**	**8.14**	**7.61**	**7.39**	**8.02**
%	**100**	**62**	**60**	**67**	**100**	**85**	**77**	**72**	**70**	**106**

Deficit irrigation (%)				Mean
100	85	75	65	SMC
9.74	7.31	6.97	7.20	7.80
Relative values of SMC				
100	75	72	74	80

Soil depth cm	Parallel		Perpendicular	
	SMC	%	SMC	%
0-30	9.15	100	9.35	100
30-60	7.42	81.1	7.90	84.5
60-90	6.17	67.5	6.82	72.9

Table 6. Crop yield and water use efficiency of date palm trees irrigated by drip or bubbler irrigation systems with different deficit irrigation treatments

Soil depth cm	Drip irrigation system					Bubbler irrigation system				
	Deficit irrigation (%)				Mean	Deficit irrigation (%)				Mean
	100	85	75	65	%	100	85	75	65	%
Crop yield in ton/fed or kg/tree										
kg/Tree	167.0	155.0	153.0	170.5	161.4	181.5	168.0	**172.0**	169.0	172.6
Ton/fed	14.9	13.8	13.6	15.2	14.4	16.2	15.0	15.3	15.0	15.4
%	100	92.8	91.6	102.1	96.6	100	92.6	94.8	93.1	95.1
Water requirement in m^3/fed of m^3/tree - season										
m^3/fed-S	1504	1279	1128	978	1222	2522	2143	123.5	1639	2049
m^3/tree-S	17.5	14.9	13.1	11.4	14.2	29.3	24.9	22.0	19.1	23.8
%	100	85.0	75.0	65.0	81.3	100	85.0	75.0	65.0	81.3
Water use efficiency in kg/m^3 of irrigation water										
kg/m^3	9.88	10.8	12.1	15.5	12.1	6.41	6.98	**8.09**	9.18	7.66
%	100	109.2	122.2	157.1	122.1	100	108.9	126.4	143.3	119.6

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دراسة مقارنة لإدارة أنظمة الري التقليدية والحديثة لري أشجار النخيل في الأراضي المستصلحة حديثا

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الكلمات الدالة: الرى بالتنقيط والرى بالببلر – كفاءة إستخدام المياه – الرى الناقص – نخيل البلح

الموجـــــــز

أجريت تجربة حقلية في تربة رملية مستصلحة حديثاً منزرعة لمعرفة أكثر نظم إدارة مياه الرى كفاءة على إنتاجية وكفاءة إستخدام المياه لأشجار نخيل البلح المثمر (عمر 12 سنة) "صنف زغلول" بالإضافة الى توزيع الرطوبة والأملاح فى القطاع الأرضى وحول الأشجار . وتتضمن نظم إدارة الرى المختبرة الرى بالتنقيط والرى بالببلر مع مستويات مختلفة من الرى الناقص 100، 85، 75، 65% من الرى الكامل.

وقد أوضحت النتائج أن متوسط قيم الاحتياجات المائية لأشجار النخيل قلت تدريجيا من 1504، 1279، 1128 و 978 فى حالة الرى بالتنقيط إلى 2522، 2143، 1891، و 1639 م^3/فدان فى حالة الرى بالببلر تحت إدارة الرى الناقص فى المستويات 100، 85، 75، 65% على التوالي. وأشارت النتائج المتحصل عليها إلى أن قيم التوصيل الكهربى فى مستخلص 1 تربة: 5 ماء (EC1:5) زاد تدريجيا مع تناقص مستويات الري الناقص من 100 الى 65٪ وزادت فى الطبقات السفلية للقطاعات الأرضية خاصة فى الطبقة 60–90 سم سواء في اتجاه مواز أو عمودي على خطوط الرى، بينما لوحظت نتائج عكسية لتوزيع رطوبة التربة.

وقد أظهرت النتائج إنخفاضًا واضحًا في إنتاجية المحصول بسبب تأثره بالإجهاد المائي المرتبط بتناقص معاملات الري من 100 إلى 85 و 75 و 65٪ بنحو 167 و 155 و 153 و 151 فى حالة الرى بالتنقيط و 182 و 168 و 172 و 169 كجم/شجرة فى حالة الرى بالببلر. وكشفت البيانات أن كفاءة استخدام المياه ارتفعت من 0.1 فى حالة الرى الكامل (100٪) إلى 0.93، 0.83 و 0.64 م^3/كجم فى حالة الرى بالتنقيط ومن 0.16 فى حالة الرى الكامل (100٪) إلى 0.14، 0.12، 0.11 م^3/كجم فى حالة الرى بالببلر مع الرى الناقص بمعدلات 85 و 75 و 65 ٪ على التوالي .

يمكن إستنتاج أن أفضل طريقة لإدارة مياه الري في أشجار النخيل "صنف زغلول" في منطقة الدراسة هي الري باستخدام نظام البلر مع الرى الناقص بمعدل 75٪ من الرى الكامل. وقد أعطت هذه المعاملة التفاعلية عائد مقبول من حوالي 172 كجم/شجرة مع توفير كمية كبيرة من مياه الري وصلت إلى حوالي 25 ٪ حيث كانت الإحتياجات المائية 1891 م^3/فدان أو 22 م^3/شجرة) مع كفاءة إستخدام مياه الرى بقيمة حوالي 8.09 كجم/م^3 .

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